Original Research Article

Energy Efficiency “Example of Adana Yüreğir Wastewater Treatment Plant(Turkey)”

ABSTRACT

The purpose of this study is to analyze the design and operating parameters for Yuregir Wastewater Treatment Plant (WWTP) of Adana Metropolitan municipality and to make a comparison of the economic analysis system. The data of Yuregir WWTP regarding the amount of treated wastewater ($m^3 month^{-1}$), the amount of produced gas (m^3/month), the energy withdrawn from the grid (kWh $month^{-1}$), and the electricity generated from the generator (kWh/month) were obtained for the year 2017. With such data, the relations of the amount of treated wastewater and energy, the amount of produced gas and energy, and the energy generated and drawn from the grid were examined. It was observed that the average amount of wastewater treated and produced gas at the facility were 2 517 831 $m^3 month^{-1}$ and 134 596 $m^3 month^{-1}$ while the generation of electricity from the generator and energy recovery as energy efficiency were 317 166 $kWhmonth^{-1}$ and 49,72%, respectively. Based upon the calculations made, it was observed that the energy consumption unit was reduced when the organic loading removal was increased at the Yüregir WWTP.

Keywords: Wastewater treatment plan; Renewable energy; Energy efficiency.

1. INTRODUCTION

The amount of wastewater resulting from the population growth and rapid industrialization is increasing day by day, and the necessity of disposing off such wastes without harming the environment is and has become a legal, social and environment up-keeping obligation. The waste sludge retained after the treatment, called as biowaste, should be disposed of in a safe manner [1]. Such wastes are usually removed and evaluated using a variety of methods. These are sanitary landfill, incineration, composting, and deep sea discharge system [2]. In the same way, wastewater treatment for developing countries is located at the beginning of the question, which is still full of unsolved. The main reason for this is the high investment and operating costs [3,4]. Depending on the energy needs with rapid urbanization and technological developments, the environment of water, soil, and air are excessively polluted such as mining operations, fertilizers and agricultural medicines used in agriculture [5,6]. Wastewater treatment plants in order to reduce wastewater damage to the environment and to ensure the continuity of the available water are becoming increasingly common. Today, a large number of systems available are applied to wastewater treatment. Activated sludge systems, stabilization ponds, trickling filters and biological systems such as anaerobic treatment are widely used for domestic wastewater treatment. Of these technologies, anaerobic digestion, which is a biological decomposition of organic matter in the absence of molecular oxygen, can be examined as one of the standard technologies for wastewater and stabilizing wastes. The products of anaerobic digestion are gases principally composed of methane (CH_4) and carbon dioxide (CO_2) and the stabilized biosolids. Anaerobic degradation may either occur in nature spontaneously or in a controlled environment such as a biogas plant. Depending on the waste stream and the system design, biogas is used as an energy source. Biogas is generally composed of approximately 55 to 65 percent methane and 30 to 40 percent carbon dioxide. Other components include nitrogen, hydrogen, hydrogen sulfide, and various other impurities.

On the other hand, stabilization ponds within developing, tropical, or subtropical climate areas are mostly preferred for domestic wastewater treatment plant [7]. The cost components and operational requirements for wastewater treatment plants are important in developed countries. Therefore, these parameters as the decision-makers play a role for the selection of treatment plant type [8], described below.

1.1 The features of treatment efficiency, energy, operation and maintenance, and flowrate of wastewater systems: the most important information needed for the process selection is collected under this title.

1.2 Treatment Level: the treatment level is determined to analyze the main wastewater parameters such as pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), nitrogen, phosphorus, etc. When selecting a treatment process, the discharge limits of wastewater into the receiving environment should be considered after identifying the treatment removal efficiencies .

1.3 Fluctuation and Reliability in Treatment Efficiency: wastewater flow and pollution characteristics show a continuous fluctuation. Therefore, the discharge standard should be supplied in statistical basis.

1.4 Other Process Requirements: required fields needs, energy issues (minimum energy use and energy shortages), easy and cost-effective availability of equipment, the trained personnel requirement, maintenance problems (machinery, equipment, etc.), sludge production and disposal (sludge treatment creates a significant part of the total treatment cost), existing hydraulic load, hydraulic head loss in the plant, treatment method, design criteria, and other related needs.

1.5 Energy Saving: energy conservation and energy saving in order to design the wastewater treatment plant should be given significant importance. A two-step approach can be applied on energy issue. The first approach, it can be done to save energy and to choose the applicable methods without increasing the cost and complexity of the treatment plant. Therefore, it should be the property of moderation in technology, process and equipment should carefully be selected, and it should be gone to useful engineering and architectural design. The second approach is to concentrate on more than just the cost analysis processes, which are more advanced equipment and devices. The feasibility of this latter approach is limited only by the developed countries. Conventional energy sources with possible wind and solar energy applications can be supported. Use of facilities for this type of alternative energy sources should be investigated for the operation of the pumps in sewage systems, ventilation motors and other equipment. Advanced devices can be used in recovering the waste heat energy. Among them, methane recovery to produce heat and power from the sludge digesters is extremely important [9].

More than 75% of WWTPs in the USA activated sludge system is used as treatment, ventilation processes in these facilities, 60% of the total electricity demand is used [10,11]. In Europe, energy consumption in urban WWTPs is around 1% of total energy consumption. It is estimated that around 0.1-0.4% of energy is used in wastewater treatment worldwide [12]. Most of the energy used in urban WWTPs is provided by the energy obtained from the anaerobic digester [12]. The energy use required for heating and lighting (electricity grid) is considered to be 6% of the plant energy consumption. [13].

The aim of this study to provide energy efficiency of the urban wastewater treatment sector in Turkey is to transform carbon footprint generating from fossil fuelsis into a neutral structure.

2. MATARIALS AND METHODS

2.1 Determination of Energy Consumption

The study was out carried with data of the Yuregir Wastewater Treatment Plant (WWTP) of Adana Metropolitan municipality, Turkey. Daily input and output flow values, total energy consumption, and the design parameters for the physical treatment units, biological treatment units, other units and the whole plant were obtained. By means of these data obtained, input pollution load and the removal efficiencies of the plant, energy value withdrawn from the grid, electricity generation of the generator, and their relationships were successfully examined. The city of Adana is between 36 ° 32 '17 .8 "- 38 ° 25 '21 .7" northern latitudes and 34 ° 39 '34 .0 "- 36 ° 24 '01 .4" east longitudes.The total amount of energy consumed in the plant was calculated by the sum of values of the transformer taken every day. Energy calculations were carried out by measuring the amount of the generator produced and withdrawn from the grid in the plant. Likewise, the removal energy values in terms of kWh m^{-3} for the total energy consumption and the amount of energy consumed per person were calculated. Monthly sewage sludge and energy values of Yuregir WWTP for the year 2017 were presented in Tables 1 and 2. A typical example of a large scale sewage treatment plant is shown in Figure 1. [14]

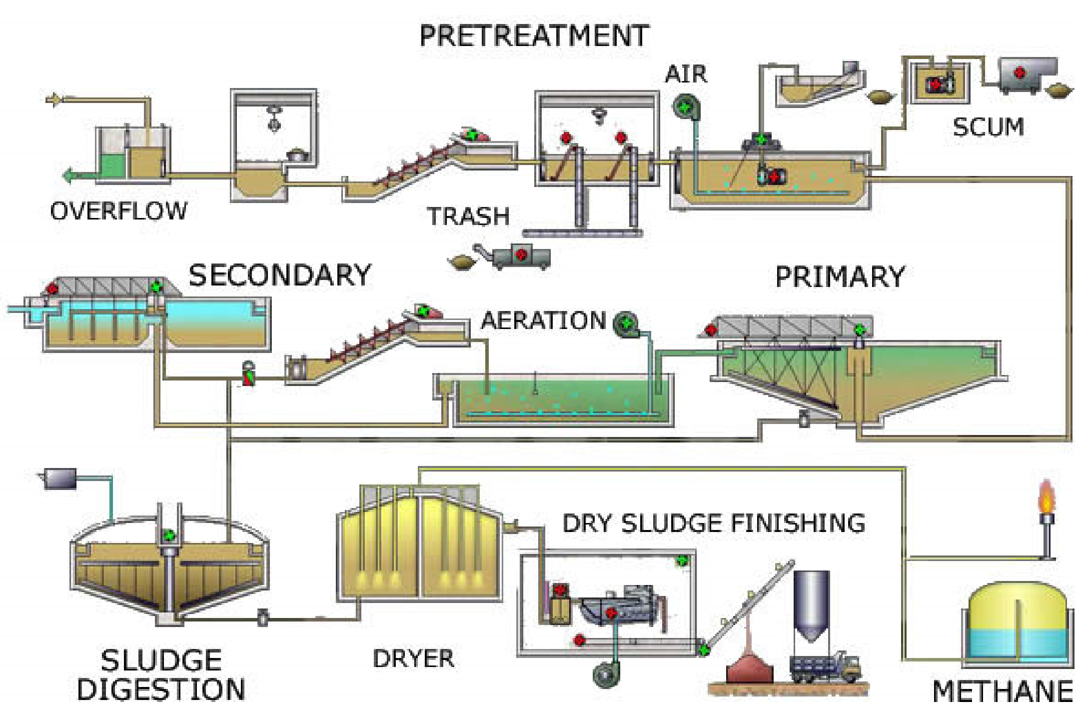

Fig. 1. Flow diagram for a typical large-scale sewage treatment plant

Table 1. Yuregir Wastewater Treatment Plant monthly sewage sludge values for the year 2017

Month	**Input Flow Rate (m^3 $month^{-1}$)**	**Amount of sludge cake (m^3 $month^{-1}$)**	**Amount of polymer used (kg $month^{-1}$)**	**Amount of biogas produced (Nm^3 $month^{-1}$)**
January	2.527.520	2.012	3.575	190.978
February	2.146.712	1.735	3.300	159.537
March	2.595.227	1.521	3.125	151.185
April	2.783.152	1.498	2.600	168.499
May	2.805.740	1.287	1.650	135.305
June	3.026.794	1.234	1.750	117.353
July	2.946.228	1.729	3.575	133.485
August	2.729.941	1.830	4.025	105.859
September	2.536.364	1.559	3.275	96.683
October	2.446.406	1.719	3.400	103.129
November	2.377.305	2.121	4.300	135.047
December	1.936.700	2.145	4.325	118.094
TOTAL	30.858.089	20.390	38.900	1.615.154
AVERAGE	2.571.507	1.699	3.242	134.596

Table 2. Yuregir Wastewater Treatment Plant energy values for the year 2017

Month	Energy Withdrawn From The Grid (kWh/month)	Generator Electricity Generation (kWh/month)	Total Energy Consumption (kWh/month)	Energy Recovery (%)	The Amount of Treated Wastewater m^3 /month	kWh/m^3
January	325.210	274.153	599.363	45,74	2.468.513	0,243
February	196.392	408.434	604.826	67,53	2.110.064	0,287
March	335.485	353.529	689.014	51,31	2.542.016	0,271
April	239.841	436.392	676.233	64,53	2.733.374	0,247
May	281.659	342.647	624.306	54,88	2.741.824	0,228
June	343.924	300.404	644.328	46,62	2.957.543	0,218
July	311.266	347.525	658.791	52,75	2.881.072	0,229
August	377.572	277.153	654.725	42,33	2.668.258	0,245
September	409.845	246.357	656.202	37,54	2.493.697	0,263
October	375.469	265.740	641.209	41,44	2.394.730	0,268
November	248.904	337.138	586.042	57,53	2.324.354	0,252
December	216.517	216.517	619.116	34,97	1.898.521	0,326
TOTAL	3.662.084	3.805.989	7.654.155	49,72	30.213.966	0,253
AVERAGE	305.174	317.166	637.846	49,72	2.517.831	0,253

Regarding WWTP Plant for the year 2017, the amount of treated wastewater in Figure 2, monthly energy values in Figure 3, monthly removal efficiency values in Figure 4, and monthly energy consumption values per m^3 treated wastewater in Figure 5 were shown.

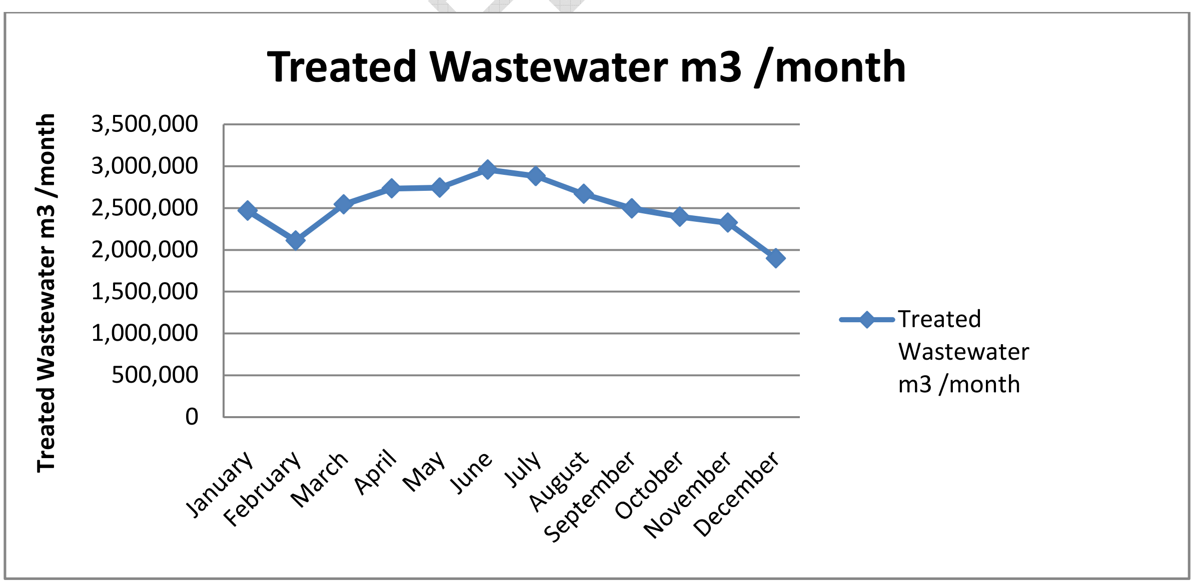

Fig. 2. Monthly values of treated wastewater of Yuregir Wastewater Treatment Plant for the year 2017

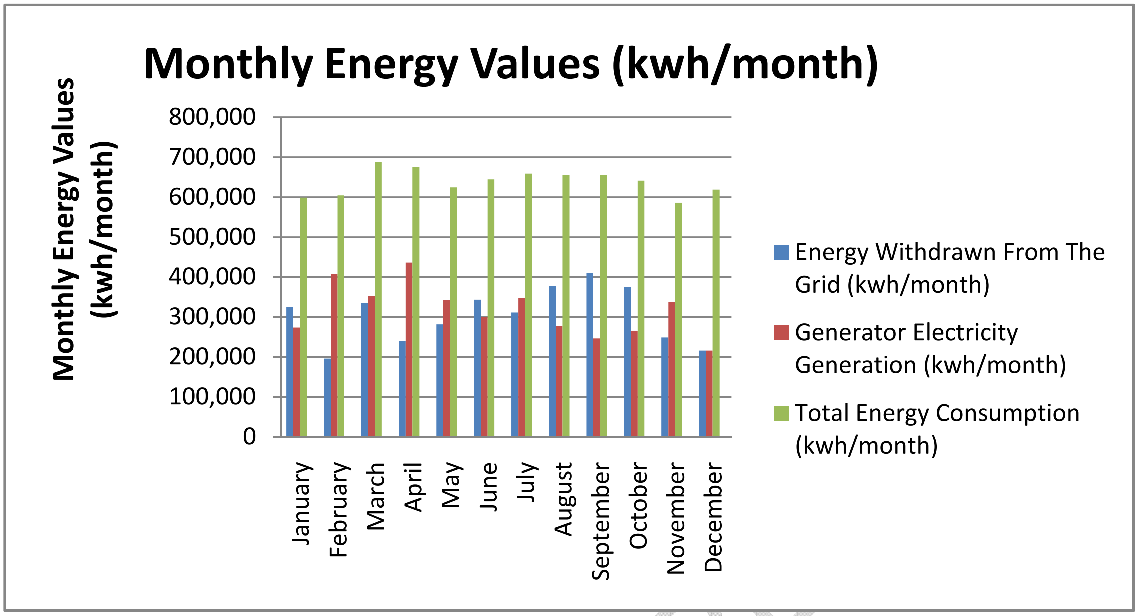

Fig. 3. Monthly values energy of Yuregir Wastewater Treatment Plant for the year 2017

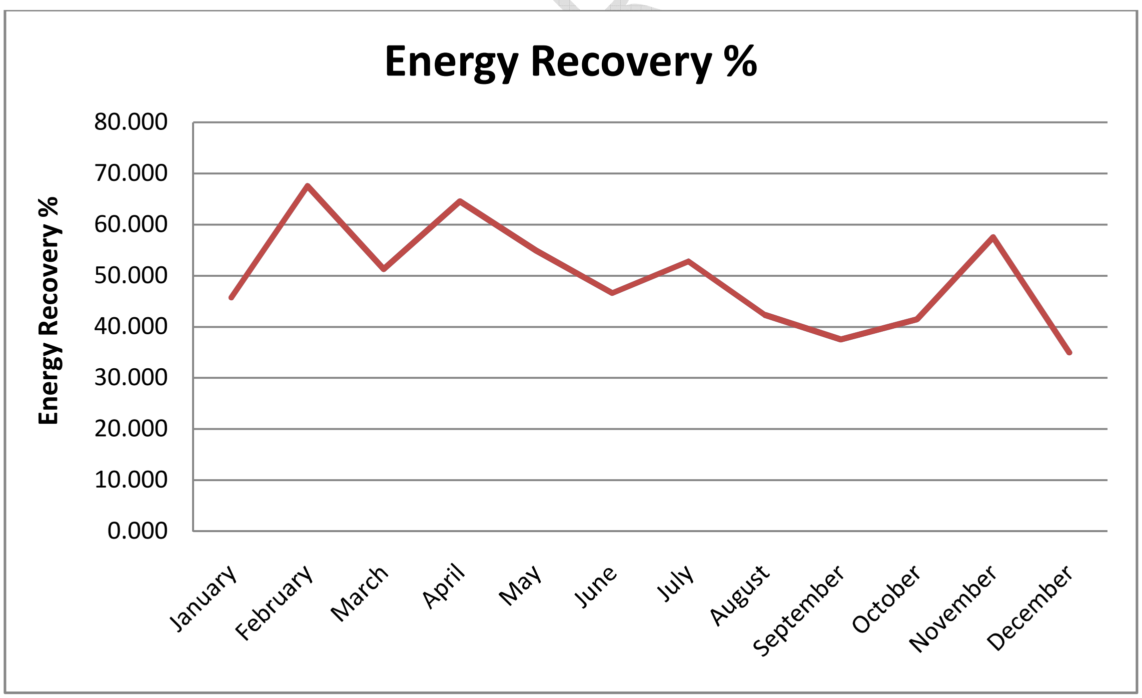

Fig. 4. Monthly values of energy recover of Yuregir Wastewater Treatment Plant for the year 2017

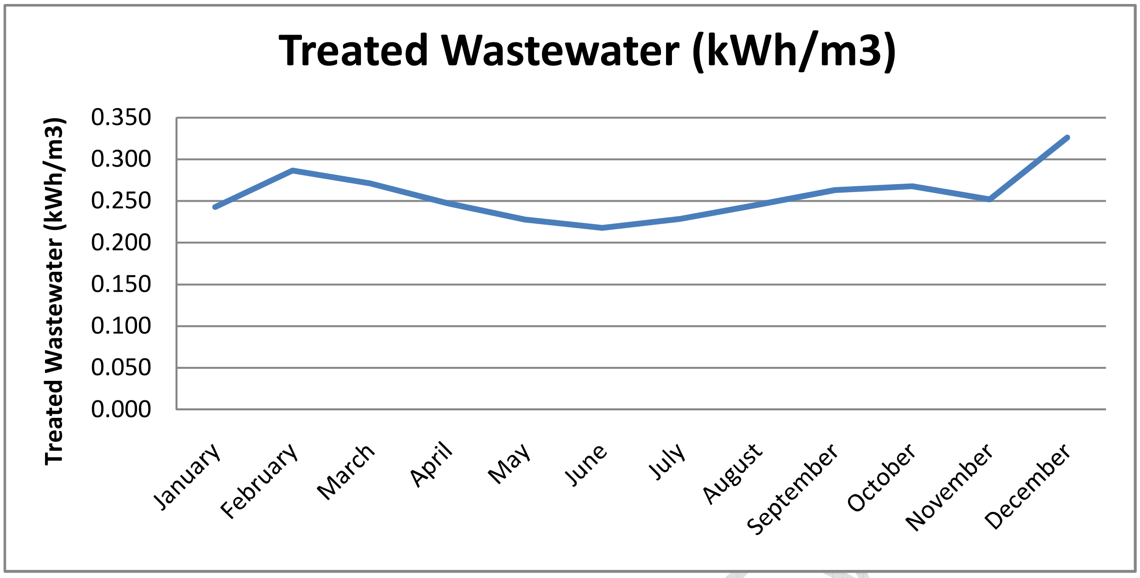

Fig. 5. Monthly values of energy consumption per m^3 wastewater of Yuregir Wastewater Treatment Plant for the year 2017

3. RESULTS AND DISCUSSION

3.1 Calculated Values Accordıng to the Data Obtained from the Plant

In this study, the energy consumption and production analysis in one of the wastewater treatment facilities of Adana were performed. For this purpose, the amount of energy consumed in the monthly time period for the year 2017 during under the titles of the physical treatment, biological treatment, and others was determined for the separate units and the whole plant. Findings belonging to the plant are presented in Tables 1 and 2 and Figures 2, 3, 4 and 5. The following conclusions are reached upon analyzing the obtained data from these tables and figures.

3.1.1 As can be seen from Figures 2, 3, 4 and 5; when the pollution load of input and output increases, the unit energy consumption is reduced as expected (although the total energy consumption increases). The increase in the pollution load reduces the unit energy consumption although the energy consumption of the plant is same. Moreover, as it can be seen again from the same tables, the consumption of operational energy for the plant is linear with the pollution load of input.

3.1.2 When examining the energy consumption of the plant, the average monthly energy consumption of 637 846 kWh is determined for the whole plant.

3.1.3 If the average monthly flow rate and energy consumption values of the plant are discussed, the amount of energy consumption per cubic meter flow for the whole plant is included. These values are found to be 2 517 831 m^3 month^{-1} (average flowrate), and 0,253 kWh m^{-3} (the total for the whole plant), respectively.

3.1.4 If the equivalent population found in design calculations and input flow coming to the plant are discussed, the amount of water consumed per person per month is included. This value for the year 2017 can be calculated as follows:

= (Average flow rate) / (Equivalent population)

= 2 517 831 (m^3 $month^{-1}$) / 588832 (person)

= 4,2759 m^3 $month^{-1}$ per person

or

= 4276 L $month^{-1}$ per person

3.1.5 If the average monthly energy consumption of the whole plant and the equivalent population found in design calculations are discussed, the amount of energy consumed per person can be found. This value for the year 2017 can be calculated as follows:

= (Average monthly energy consumption) / (Equivalent population)

= 637 846 (kWh $month^{-1}$) / 588 832 (person)

= 1,083 kWh per person

or

= 1 083 W per person

4. CONCLUSIONS AND RECOMMENDATIONS

The aim of this study to provide energy efficiency of the urban wastewater treatment sector in Turkey is to transform carbon footprint generating from fossil fuelsis into a neutral structure. The recommendations in the field of urban wastewater treatment are also included aimed at designing and operating criterion for energy consumption, increasing the energy efficiency of wastewater treatment plant, and reducing CO_2 emissions. At the same time, it is expected to benefit from this study that the sustainable investments on the basis of energy efficiency to be made to the urban wastewater treatment system facilitate given a consistent standard. As a result of this process, having detected the measures for energy efficiency is one of the important outcomes obtained in wastewater treatment industry. Another important issue for the implementation of energy efficiency measures in wastewater treatment industry is to ensure cooperation among the main stakeholders. In this regard, all stakeholders are substantially required to commitments to go to reduce in energy consumption. Furthermore, it should not be prohibitive nature of necessary legislation regarding the implementation of measures for energy efficiency [15]. The construction and operation of wastewater treatment plants are processes that require a high cost. Therefore, the most suitable process to be able to minimize construction and operation costs in the feasibility reports of the treatment plants must be selected. The facility should also be built with the appropriate mechanical equipment to process. Yuregir Wastewater Treatment Plant of Adana Metropolitan municipality is a plant operating with activated sludge system. High energy - operating costs in applying the activated sludge treatment plant is known. However, this system that can meet the high flow rate for small volumes was deemed appropriate for Yuregir Wastewater Treatment Plant. As a result of research findings obtained from the plant the removal efficiency for the whole plant was found maximum with the average average of 67,53% in February 2017 while the annual average was found to be 49,72% . Energy expenditure of 305174 kWh/m^3 was determined by taking the monthly average energy consumption of the plant. Likewise energy expenditure for 1 m^3 was calculated as 0,253 kWh by taking into account of the plant with the daily average flow and the total energy consumption. According to average daily flow from the plant and equivalent population, per capita water consumption of 4276 L $month^{-1}$ was found. The amount of energy expended per person per month in wastewater treatment was found to be 1083 W according to the total energy consumption used in the plant and the population equivalent value of the project. In accordance with data obtained from the plant, the unit energy consumption is reduced when organic loading is increased in the plant. It should not be much of effort to reduce organic pollution load to protect the plant from the negative factors and the increase of pollution per person in the future [16]. The awareness should be created about the opportunities and benefits to be derived from energy efficiency in the wastewater treatment field. The operation of wastewater treatment plants accordance with the principles of energy efficiency should also effectively be provided (operators training). Finally, the design and engineering firms operating in wastewater treatment field should be informed on the subject. Thus, the effective and efficient use of energy are supposed to be included in future projects.

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