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New Method for Biogas Generation from Municipal Wastewater Treatment Plant of Isfahan City, Iran

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Abstract

Protection of Environmental and decreasing the greenhouse gases is a practice of protecting the natural environment on individual, organizational or governmental levels, for the benefit of both the natural environment and humans. The present study is about biogas generation from municipal wastewater treatment plant of Isfahan city via anaerobic procedure. As we know, large amounts of waste sludge, containing organic and mineral components, are produced by municipal wastewater treatment plants. Anaerobic & Aerobic fermentation has been used for wastewater treatment. Aerobatic digestion is the biological decomposition of organic content of wastewater in the absence of oxygen which produces methane, Ammonia, hydrogen sulfide etc. Therefor municipal wastewater could be used as a source of biogas energy. The flow rate of inlet wastewater to Isfahan wastewater treatment plant is 1500 L/Sec. After construction and utilization of Isfahan biogas plant, 450 m^3/h, biogas is produced. The composition of biogas is 69.1% Methane, 28.3% Carbon dioxide, 2.6% Nitrogen and trace Hydrogen Sulfide. The Annual capacity is equal to 2,250,000 Nm3/Year of natural gas. The estimation shows that in case this amount of biogas is used as a fuel of power plant, it generates 1200Kw/h electricity power. On the other hand if we consider the volume of 885 Mm3/year of municipal wastewater in Iran, then it could generate 170,666 Mw/hr electricity power. As a result huge amount of fossil fuel could be saved for the next generation and production of greenhouse gases would considerably decreases.

Keywords: *Biogas, Municipal wastewater, Water treatment plant, Sludge, Sewage, Sewerage, Anaerobic digestion, Methane, Energy.*

1. INTRODUCTION

One of the major problems in making use of new energies consists in discontinuity, hard accessibility and high cost of such energies in most countries across the world. But the energy generated from the biogas produced from waste water treatment, due to continues swage production process in cities, is presently considered as a new constant source of energy. Biogas is generated due to anaerobic fermentation and decomposition of organic matter by means of anaerobic bacteria, especially methanogen bacteria [1, 2]. Annual potential biogas production out of all processes in Europe is estimated over 200 billion m^3. With regard to statistics issued by the European Union, Germany and Denmark have been found to have highest rate biogas obtained from sludge, proportional to their population, though Italy, Spain and France, with respect to their population being similar to other countries, have indicated good performance [3, 4].

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In Iran, based on study made by ministry of power, the potential biomass has been estimated equal to 74 million barrels of crude oil for agricultural wastes, 15 million barrels of crude oil for municipal waste, 55 million barrels of crude oil for the waste of food industries and 2 million of barrel crude oil for urban sewages. Sewage sludge as well as waste from water treatment plant can be considered, as a permanent source of biogas. According to the statistics made by the Iranian Water and Waste water Organization, the population covered by sewerage installations in Iran are 21,363,000 person, taking around 38.2% of the country total population. Total volume of the collected sewage is 2,794,888 m^3/day. The volume of produced biogas and its generated electricity can be calculated on the basis of BOD_5, COD and its ingredients, i.e. a minimum potential of biogas production of about 40 million m^3 per year[5].

In this study biogas production from urban sewage and application of online monitoring system as a new method in Iran is reported.

2- BIOGAS PRODUCTION IN SEWAGE TREATMENT PLANT

Sewages, depending on their specifications are divided into 3 groups: domestic, industrial and surface water sludge. Biological treatment is the most effective method to reduce organic content found in waste water sewages. The treatment methods based on the type of microorganisms are divided in to aerobic and anaerobic. In aerobic digestion, the microorganisms are the main factor for decomposing reaction and the energy resulting from this metabolism used for their survival. The products of such metabolism are carbon dioxide, water and ammonia. Some part of the organic the organic substances used for formation new cells.
The conversion process of organic wastes into biogas energy is called anaerobic digestion in absence of oxygen, which capable of being used industrially and domestically. Major characteristics of anaerobic digestion include decreasing of mass, generating of biogas and improving of water absorption properties from treated sludge. There are four main chemical and biological stages in the process of anaerobic digestion: hydrolyze, Acidosis, Acetonyze and methanogenize which occur in two temperature ranges of 22-35 C and 50-70 C [4, 6, 7].

Various factors affected the rate of the composition of produced biogas such as temperature, pressure, pH, ratio of carbon and nitrogen, retention time and sewage charging rate [8]. Methane production is sensitive to temperature, so it is necessary that the temperature in digesters is continuously monitored. The most favorite range of pH for producing methane is 6.8 to 7.2 and the best ratio of carbon to nitrogen in raw materials is 30:1. Hydraulic retention time can be determined as the amount of raw materials which need to be added each day, over charging of raw materials into digester stopping of biogas production [6, 9].

3. BIOGAS PRODUCTION IN ISFAHAN SEWAGE TREATMENT PLANT

The sewage treatment plant of Isfahan has nominal capacity of 1,200,000 persons and an incoming flow rate of approximately 1,500 Lit/sec consists of two operation stages [10].

The treatment system operates by an ordinary active sludge method with pumping unit station, trash separator, sand interception, primary sedimentation and biological treatment unit which is designed with an hydraulic retention time of 4 to 6 hours. Two types of sludge are produced in Isfahan sewage treatment plant: primary and secondary sludge. These sludge, are pumped towards the heat exchanger by means of centrifugal pump, in order to heat the sludge to a mesophilic temperature of 30-40 °C, since biochemical reactions and methane production are the best achieved at this temperature [11]. Hot water is circuited in the heat exchanger pipes at 50-60 °C so that the sludge will heat up. The retention time of sludge in digesters is 20 d, during this period the sludge is stabilized and biogas generated.

Fig 1. Sewage treatment plant & biogas digester

4-MATERIALS AND METHOD

Anaerobic digestion

Five samples of each sludge, i.e. Primary and Secondary, were taken and analyzed by standard method. Sludge properties are given in Table 1.

Table 1. Properties of Isfahan sewage treatment sledge

Type	Dry Content (kg/day)	Sludge %	m^3/day
Primary	46244	0.6	7405
Secondary	13180	0.5	2510

These sludges consist of 99.5% of water so that they are send to concentration ponds. After two days sludge is sent to the anaerobic digester. The digester capacity is 6000 m^3 with 20 days of HRT. In this period temperature of the sludge is set to 30-40 °C, and acidity, organic content of inlet and outlet sludge are controlled. Under these conditions 450 m^3/h of biogas is produced; biogas analysis is given in Table 2.

Table 2. The Chemical property of produced biogas

Sample	CH_4% v/v	C_2H_4% v/v	C_3H_6% v/v	CO_2% v/v	CO% v/v	N_2% v/v	H_2S (mg/L)
	69.1	Not detected	Not detected	28.3	Trace	2.6	720

5-PROCESS CONTROL

Sewage sludge and anaerobic digestion plant are monitored by the installation of an on-line monitoring system. This system allows taking samples, carrying out continuous analysis of sewage sludge and save results in a memory The results can be then transmitted to the monitoring centers through networks [12-15].

The central automation systems controls the processes, giving commands to different pumps, motors, aeration equipment, mixers, electric valves and other equipment; in addition it prevents the occurrence of accidents, damages to the process, operators errors, leaking, inefficiencies or failures, and meeting the stability of the system to produce thermal and electrical energy [13].

The entire system can be divides in operative units that are connected to each other as indicated in the following chart:

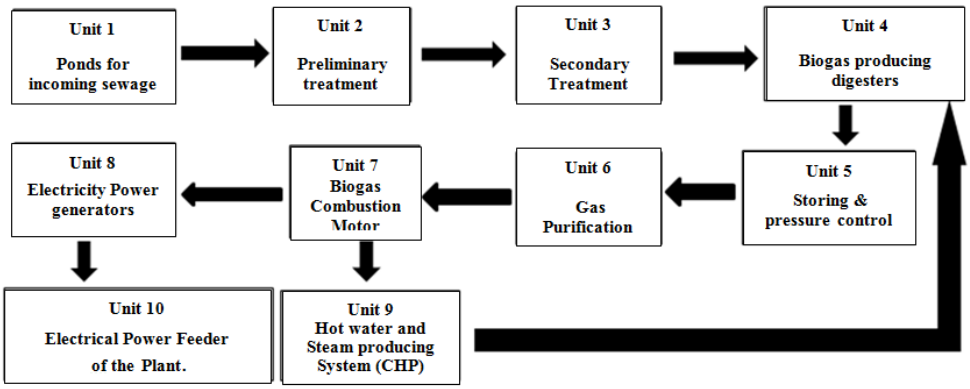

Fig 2. Schematic view of the units under control

Considering the above scheme, it can be observed that each unit can be controlled and monitored separately, but, also, they can be integrated. The availability of such control system can ensure stability and safety of the whole system.

6. ENERGY PRODUCTION IN THE ISFAHAN SEWAGE TREATMENT PLANT

There are two type of sludge in Isfahan sewage treatment plant. Primary sludge that consist in 46,224 kg of dry solid per day and secondary sludge that consist in 13,108 kg of dry solid per day, so that the total amount

of sludge is 59,332 kg /day. On the other hand, approximately 10,000 m^3 of additional sludge are produced per day which should be removed out of the plant [10]. Taking into consideration the total sludge availability and using two anaerobic digesters there is the capacity in producing 225,000 m^3 of biogas per day, which have the potential for generating electricity. By using two biogas combustion motors with a nominal generating power equal to 620 kW capable of generating 1200 kW electricity. Thus, by considering 8,000 working hours per year, 9,600,000 kW h of electricity are generated annually.

Furthermore, the exhaust gases coming from biogas combustion have a temperature of 447 °C that by using CHB system provides the possibility of heat recovery and supplying hot water to heat sludge inside the digesters. By adding an absorption chiller and combining the system with the simultaneous production of power, heat and cooling of air conditioning system of office and buildings of sewage treatment plant can be provided.

The amount of investment required for the above mentioned project including the establishment of the system for simultaneous production of power and energy (CHP) is equal to 900,000 EURO which can be anticipated to return within a period not more than 30 months.

7. CONCLUSION

Taking Into consideration the existing crises in connection with the energy subject matter, making use of modern and renewable energies, is one of the important subjects of the present day across the world. Utilization of system producing biogas from municipality sewage, due to continuity of such sewage, is considered as one of the safest methods of generating renewable electricity. With regard to the statistics issued by Ministry of water and wastewater of Iran water, the population under coverage of sewerage in Iran is around 2.794.888 m^3 every day. Minimum potential of biogas production is about 40 million m^3 per year, therefore the energy generation from such amount of municipal sewage in Iran can be estimated approximately around 170.666 Mw/h of electrical energy per year and 742.000 GJ of thermal energy per year. As a result huge amount of fossil fuel could be saved for the next generation and production of greenhouse gases would considerably decreases.

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