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PRODUCING BIOGAS BY APPLYING ELECTRICAL CHARGE

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Abstract: *The paper reviews the methods of applying electrical charge to manure, which is important part of the anaerobic fermentation, in order to produce biogas. During the experiments, different voltages are applied to the manure. The aim is to investigate the influence of the electrical charge with manure. It's believed that the electric charge improves the process of anaerobic digestion and results in higher yield of biogas with higher methane content. The experiment consists of two main parts: part one is the plant material, which is treated with acid and part two which is the manure treated with electric charge. After the two materials are treated, they are mixed and placed in glass bottles, which are hermetically closed and attached to biogas collectors. Then the bottles are placed in a water bath at 35 ° C. Samples were taken daily for analysis.*

Keywords: *Biogas, plant material, electric charge, methane content*

INTRODUCTION

Biofuels today represent a great share of the energy carries in modern and developed society. They are considered as an alternative to the conventional fuels like coal, oil and nature gas. People have used to burn traditional fuels for even centuries. Since the first fire, made by gathering some woods, then by discovering the coals and later the oil and nature gas, people have build their society and development, relying on those energy resources. Thanks to them, today we have created the world, we know today. A world in which energy is important issue and plays vital role in our economy and society. It will not be farfetched, if we say that today world could not exist without energy. But the use of energy comes with a price – polluting the environment. As the world is believed to be almost 8 billion people, and it consumes almost 100 million barrels per day, the pollution is on worldwide scale. It affects the entire planet – causing greenhouse effect, mainly by directly burning fuels, by destoying forests in order to provide more space for living and agricultural needs, to changing the worldwide climate – the global warming we observe today. One way to reduce the greenhouse emmissions is by using alternative, less pollutive and even cleaner fuels. Fuels like biogas, for example. Biogas is produced from manure, agricultural waste, municipality and some of the industrial waste, as well as a combination of them. It contains methane (the main ingredient). The current paper focuses on the research of obtaining biogas by mixing different types of waste and by applying also different types of their treatment. The process is called anaerobic digestion, and the final and most valuable product is the biogas. As it is produced from biomass which is cultivated today, biogas is carbon neutral, because coal, oil and nature gas are produced from organic material for millions and millions of years. Yet in the same time, they are burned in less than two centuries.

EXPOSITION

Investigation of Applying Electrical Charge to Manure in Anaerobic Digestion

Experiment 5

The coniferous material is shredded with a chopper. This treatment is needed in order to make the organic material more easily accessible for the following acid hydrolysis treatment and also to be more accessible by the microorganisms. After the shredding is finished, 16 g are checked on scales and placed in a flask, then a solution of 100 ml of 1% of sulphuric acid is added to the flask. Then the flask is placed in autoclave for 20 minutes, at 121 °C. After the autoclave treatment

is over, the flask is taken out and left to cool down. In the meantime, the manure is treated with electrical charge for ½ hour at 0.75 V. When the flask is cool enough, the electricaly treated manure (300 g) is poured into a glass bottle, which will serve as bioreactor vessel. Then 8 g of glycerol are added as a cosubstrate. Then the bioreactor is placed in water bath and it is also connected with pipes to cylinder wich will serve as gasholder. Samples were taken for analisys.

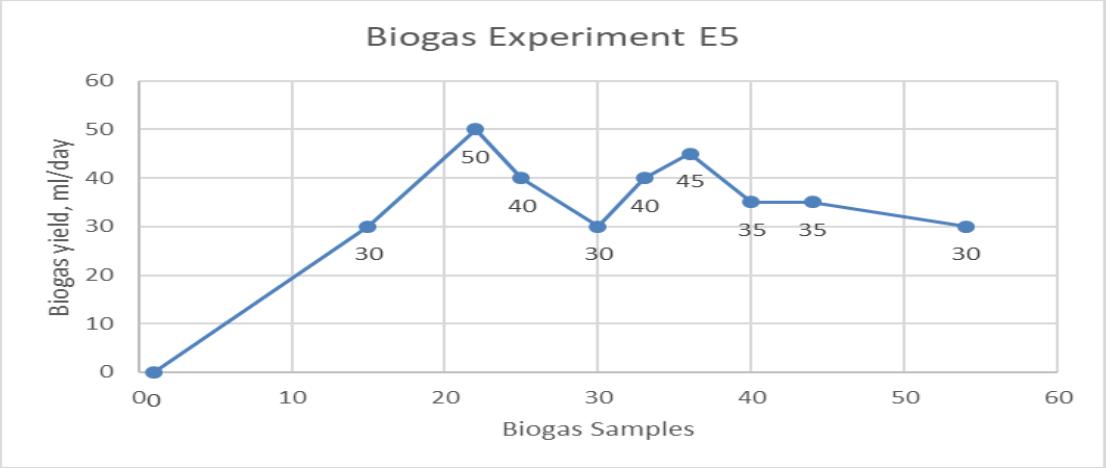

Fig.1 Biogas results for experiment 5

Feeding scheme:
16 g conf. material + 100 ml 1% H_2SO_4 + 8 g glycerol + 300 g manure (0.75V, 1/2h)

The total biogas volume: 335 ml,
Total mass of the feeding material: 324 g
Yield, L/kg (ml/g): 1.03

Experiment 6

The coniferous material is shredded with a chopper. This treatment is needed in order to make the organic material more easily accessible for the following acid hydrolysis treatment and also to be more accessible by the microorganisms. After the shredding is finished, 16 g are checked on scales and placed in a flask, then a solution of 100 ml of 1% of sulphuric acid is added to the flask. Then the flask is placed in autoclave for 20 minutes, at 121 °C. After the autoclave treatment is over, the flask is taken out and left to cool down. In the meantime, the manure is treated with electrical charge for ½ hour at 1 V. When the flask is cool enough, the electricaly treated manure (300 g) is poured into a glass bottle, which will serve as bioreactor vessel. Then 8 g of glycerol are added as cosubstrate. Then the bioreactor is placed in water bath and it is also connected with pipes to cylinder wich will serve as gasholder. Samples were taken for analisys.

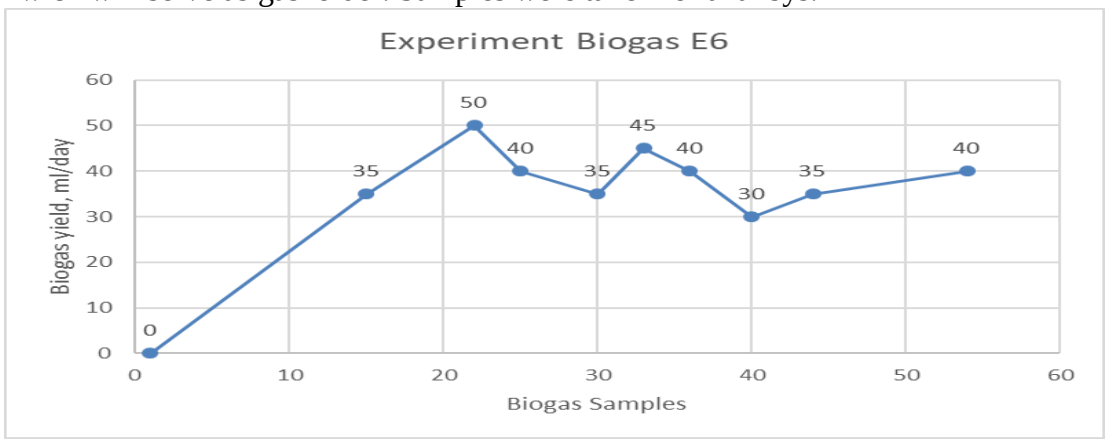

Fig.2 Biogas results for experiment 6

Feeding scheme:
16 g conf. material + 100 ml 1% H_2SO_4 + 8 g glycerol + 300 g manure (1V, 1/2h)

The total biogas volume: 350 ml,
Total mass of the feeding material: 324 g
Yield, L/kg (ml/g): 1.08

Experiment 7

In this and the next several experiments, the plant material is changed with straw. The purpose for that is to research how materials from different plant origin would behave according to the treating procedures and what results would be obtained regarding biogas production. The treatment includes the very same steps as with the coniferous material. The straw is shredded with a chopper. After shredding, 16 g of straw material are weighted on scales and placed in a flask, then a solution of 1% H_2SO_4 100 ml are added to the flask. The the flask is placed in autoclave for 20 minutes at 121 °C. After the autoclave is finished, the flask is left to cool for some time. When the flask is cool enough, 8 g of glycerol (waste glycerol) are added to the flask. After that 300 ml of cattle manure are poured into the flask. Then the flask is placed in water bath and it is also connected with pipes to cylinder which will serve as gasholder. Samples were taken for analysis.

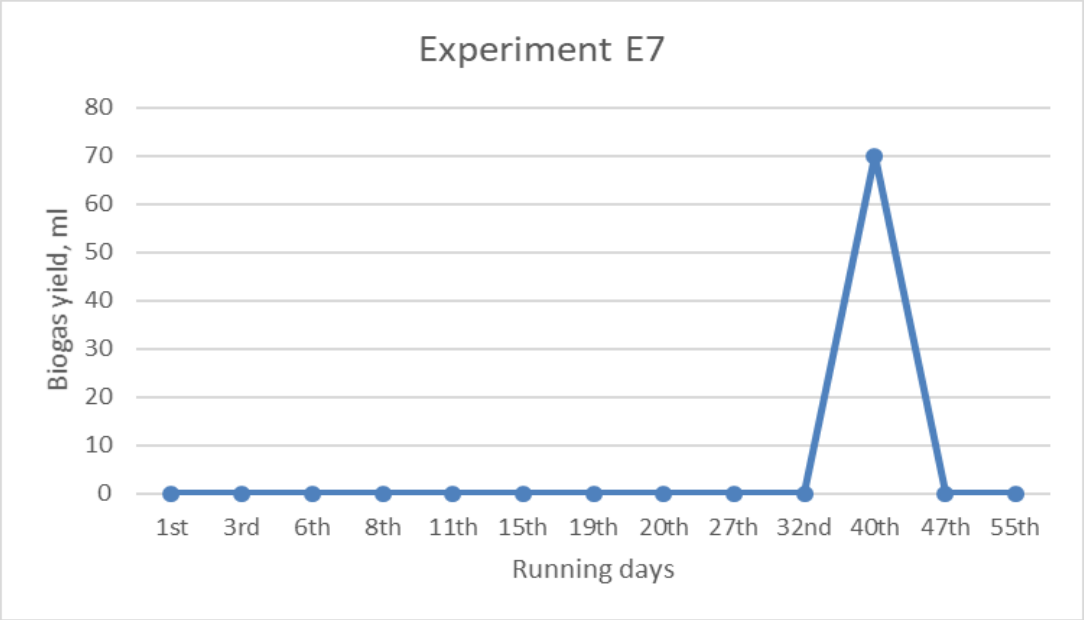

Fig.3 Biogas results for experiment 7

Feeding scheme:
16 g straw + 100 ml 1% H_2SO_4 + 8 g glycerol + 300 g manure (no DC)

The total biogas volume: 70 ml,
Total mass of the feeding material: 324 g
Yield, L/kg (ml/g): 0.22

(for conclusion: in this experiment, electricity treatment is not performed in order to be able to compare it with later experient with the same feeding scheme with the addition of electrical treatment, E7 serves as blank set, because it's the first time to use straw, so comparison between straw without and with electrical treatment)

Experiment 8

The straw is shredded with a chopper. After shredding, 16 g of straw material are weighted on scales and placed in a flask, then a solution of 1% H_2SO_4 150 ml are added to the flask. Then the

flask is placed in autoclave for 20 minutes at 121 °C. After the autoclave is finished, the flask is left to cool for some time. When the flask is cool enough, 16 g of glycerol (waste glycerol) are added to the flask. After that 300 ml of cattle manure are poured into the flask. Then the flask is placed in water bath and it is also connected with pipes to cylinder which will serve as gasholder. Samples were taken for analysis.

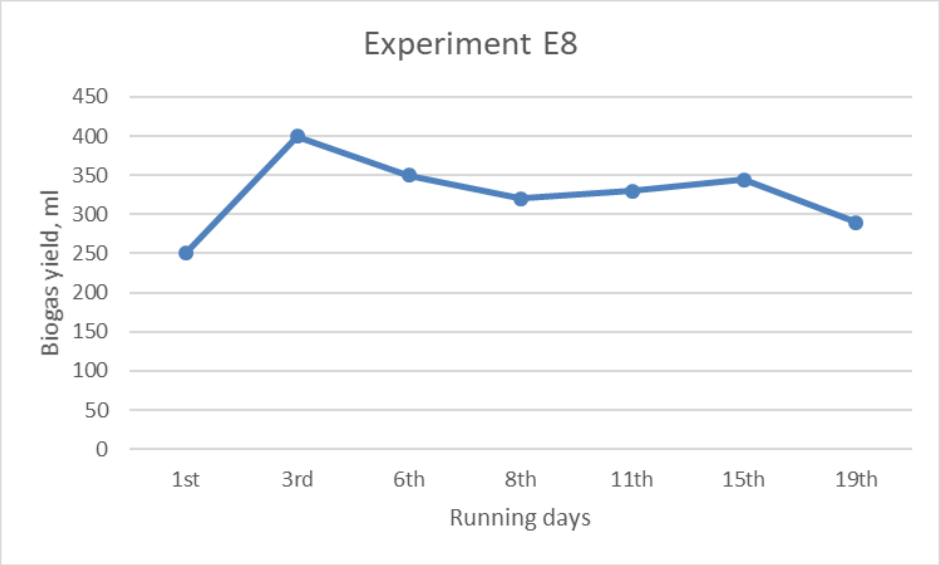

Fig.4 Biogas results for experiment 8

Feeding scheme:
16 g straw + 100 ml 1% H_2SO_4 + 8 g glycerol + 300 g manure (no DC)

The total biogas volume: 2284 ml,
Total mass of the feeding material: 324 g
Yield, L/kg (ml/g): 6.88

Experiment 9

The straw is shredded with a chopper. After shredding, 32 g of straw material are weighted on scales and placed in a flask, then a solution of 1% H_2SO_4 200 ml are added to the flask. The the flask is placed in autoclave for 20 minutes at 121 °C. After the autoclave is finished, the flask is left to cool for some time. When the flask is cool enough, 16 g of glycerol (waste glycerol) are added to the flask. After that 300 ml of cattle manure are poured into the flask. Then the flask is placed in water bath and it is also connected with pipes to cylinder which will serve as gasholder. Samples were taken for analysis.

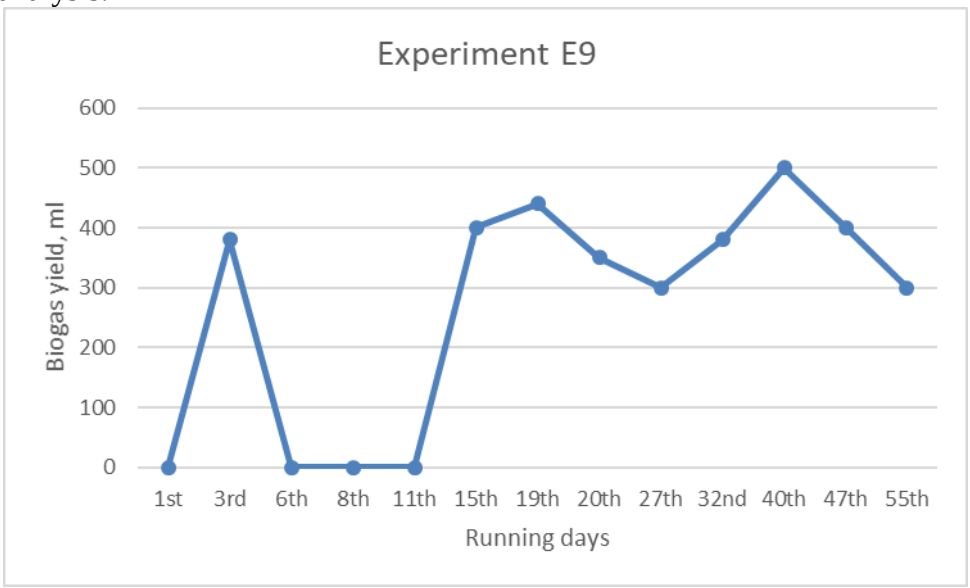

Fig.5 Biogas results for experiment 9

Feeding scheme:
32 g straw + 200 ml 1% H_2SO_4 + 16 g glycerol + 300 g manure (no DC)

The total biogas volume: 3450 ml,
Total mass of the feeding material: 348 g
Yield, L/kg (ml/g): 9.91

Experiment 10

The straw is shredded with a chopper. After shredding, 16 g of straw material are weighted on scales and placed in a flask, then a solution of 1% H_2SO_4 150 ml are added to the flask. The the flask is placed in autoclave for 20 minutes at 121 °C. After the autoclave is finished, the flask is left to cool for some time. When the flask is cool enough, 8 g of glycerol (waste glycerol) are added to the flask. After that 300 ml of cattle manure (DC 0.5V ½ h) are poured into the flask. Then the flask is placed in water bath and it is also connected with pipes to cylinder which will serve as gasholder. Samples were taken for analysis.

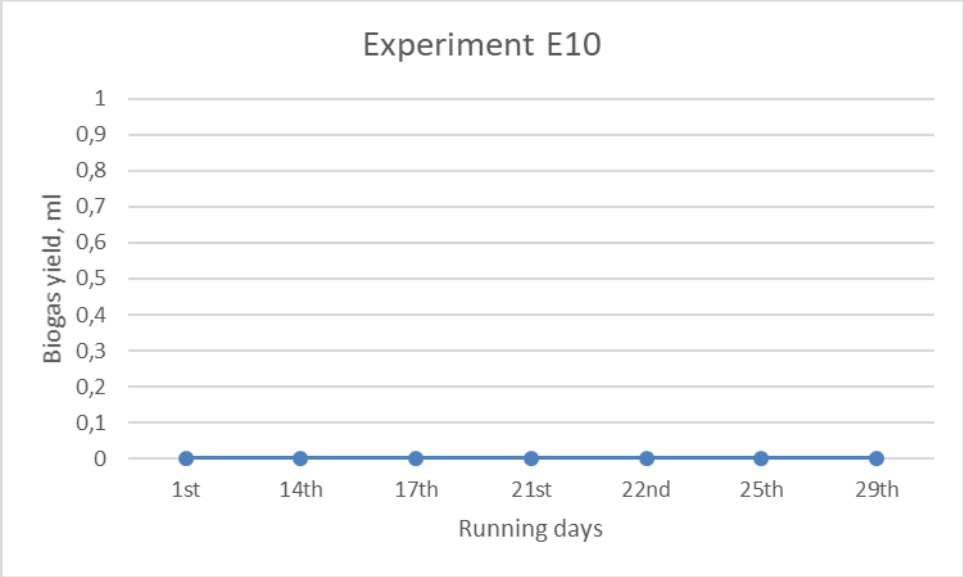

Fig.6 Biogas results for experiment 10

Feeding scheme:
16 g straw + 150 ml 1% H_2SO_4 + 8 g glycerol + 300 g manure (DC 0.5V ½ h)

The total biogas volume: 0 ml,
Total mass of the feeding material: 324 g
Yield, L/kg (ml/g): 0

Experiment 11

The straw is shredded with a chopper. After shredding, 16 g of straw material are weighted on scales and placed in a flask, then a solution of 1% H_2SO_4 150 ml are added to the flask. The the flask is placed in autoclave for 20 minutes at 121 °C. After the autoclave is finished, the flask is left to cool for some time. When the flask is cool enough, 16 g of glycerol (waste glycerol) are added to the flask. After that 300 ml of cattle manure (DC 0.5V ½ h) are poured into the flask. Then the flask is placed in water bath and it is also connected with pipes to cylinder which will serve as gasholder. Samples were taken for analysis.

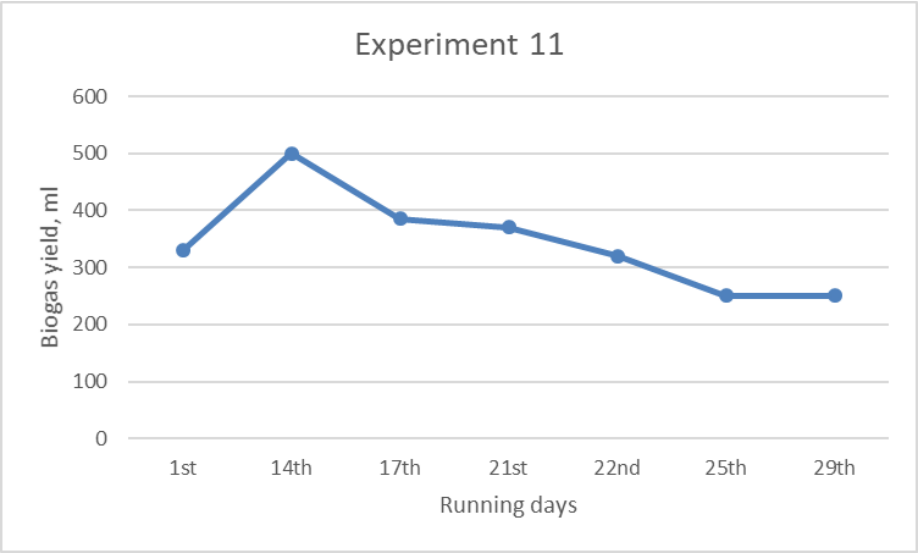

Fig.7 Biogas results for experiment 11

Feeding scheme:
16 g straw + 150 ml 1% H_2SO_4 + 16 g glycerol + 300 g manure (DC 0.5V ½ h)

The total biogas volume: 2405 ml,
Total mass of the feeding material: 332 g
Yield, L/kg (ml/g): 7.24

Experiment 12

The straw is shredded with a chopper. After shredding, 32 g of straw material are weighted on scales and placed in a flask, then a solution of 1% H_2SO_4 200 ml are added to the flask. The the flask is placed in autoclave for 20 minutes at 121 °C. After the autoclave is finished, the flask is left to cool for some time. When the flask is cool enough, 16 g of glycerol (waste glycerol) are added to the flask. After that 300 ml of cattle manure (DC 0.5V ½ h) are poured into the flask. Then the flask is placed in water bath and it is also connected with pipes to cylinder which will serve as gasholder. Samples were taken for analysis.

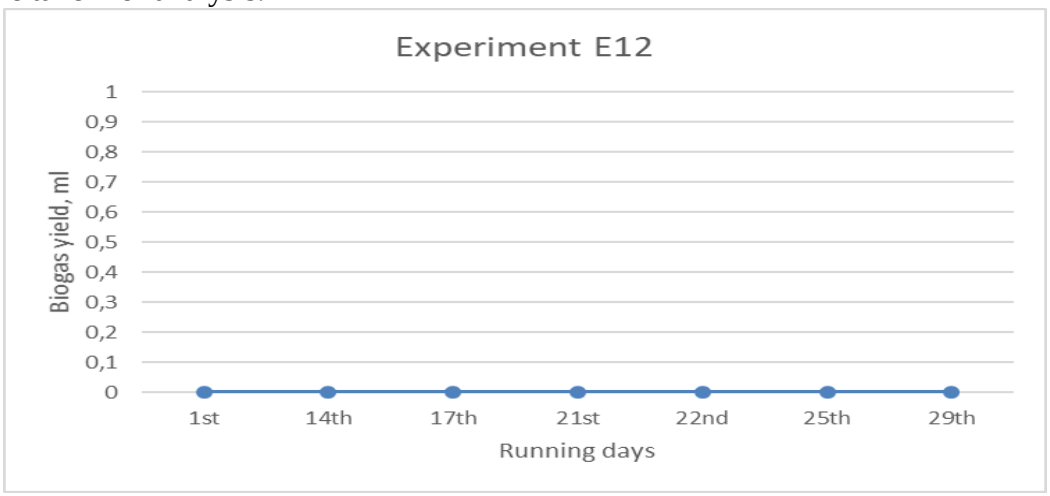

Fig.8 Biogas results for experiment 12

Feeding scheme:
32 g straw + 200 ml 1% H_2SO_4 + 16 g glycerol + 300 g manure (DC 0.5V ½ h)

The total biogas volume: 0 ml,
Total mass of the feeding material: 348 g
Yield, L/kg (ml/g): 0

Table 1 A schematic view of the feeding scheme and obtained results

Parameter	Voltage 0,75 V	Voltage 1 V	Voltage 0.5V*
Yield, L/kg (ml/g)	*1,03*	*1,08*	*8.54*
Feeding scheme	*16g conf. mat (100 ml 1% H_2SO_4) + 8 g glycerol + manure 300 g*	*16g conf. mat (100 ml 1% H_2SO_4) + 8 g glycerol + manure 300 g*	*16g conf. mat (100 ml 1% H_2SO_4) + 8 g glycerol + manure 300 g*
Total biogas volume	*335 ml*	*350 ml*	*2770 ml*

CONCLUSION

The purpose of the carried experiments was to determine the influence of electrical charge to the process of anaerobic digestion in conjuction with mixing plant waste (as main substrate), glycerol (as cosubtrate) and manure (as cosubtrate). In both experiemnts, the accumulated amount of biogas is close, and also the yield. The burning test in both experiments showed low results. Very little amount (around 10%) of the total biogas were flammable. The most probably cause for that might be the very hight voltage used in the experiments. In previous experiments, it was observed that voltage of 0.5V have given much better results. That lead us to the conclusion that, 0.5V might be the optimum voltage for anaerobic digestion.

REFERENCES

Biogas Handbook Authors: Teodorita Al Seadi, Dominik Rutz, Heinz Prassl, Michael Köttner, Tobias Finsterwalder, Silke Volk, Rainer Janssen ISBN: 978-87-992962-0-0 Published by University of Southern Denmark Esbjerg, Niels Bohrs Vej 9-10, DK-6700 Esbjerg, Denmark

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Karena Ostrem, Prof. Nicholas J. Themelis, Greening waste: anaerobic digestion for treating the organic fraction of municipal solid wastes, Department of Earth and Environmental Engineering, Foundation of School of Engineering and Applied Science, Columbia University, May 2004

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