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THE QUALITY PARAMETER CHANGES OF LANDFILL GAS PRODUCED AT THE REFUSE DUMP REGARDING RELATIVE AIR HUMIDITY

T. Molnár

University of Szeged Faculty of Engineering, Technical Institute, Mars str. 7., 6724, Szeged, Hungary

e-mail: molnart@mk.u-szeged.hu

ABSTRACT

The purpose of my research is to examine the quantity and methane content of landfill gas originating from the characteristic organic matter potential, weather parameters and exploitation technology used in the region and by that, determine useful relationships. Results are defined in working dimensions where the quality and quantity of landfill gas is defined by the efficiency of the extraction system, environmental conditions, the composition of waste and the technology of unloading. The theoretical and practical phenomenon confirms that processing the generated waste by modern European Union-compliant technology systems can be used as alternative energy instead of fossil energy sources to produce electricity and heat. The quality and quantity of biogas presumably depends on the weather parameters of the refuse dump, the technical parameters of the biogas recovery system and the organic matter content, typical of the Hodmezovasarhely region.

Keywords: landfill gas, alternative energy, environmental conditions, relative air humidity, friction, stiction

1. INTRODUCTION

The external characteristics of the refuse dump and its environment were relevant such as weather data between which I looked for connections by mathematical statistical methods. The refuse dump can be considered as a natural bio reactor where not only biological processes but also external conditions have their influence. Because of this it was necessary to examine each external condition and compare them with the measured gas compositions. The results of these examinations can be used at both existing and planned refuse dump sites. For diagnosing the degradation process in the refuse dump and optimizing energy recovery I used a GA2000 type NDIR (Non Dispersive Infra Red) analyzer, working in the medium infrared region [3]. The data was statistically processed with SPSS for Windows 11.0 program was used. The data was processed by the method of analysis of variance Homogeneity was examined with the Levene-test [2]. When comparing the group-couples Tamhane test (in case of heterogeneity), and LSD test (in case of homogeneity) were applied. The tightness between variables was determined by linear regression analysis. In my examinations I calculated the necessary number of data by using a method by [6]. In order to be able to determine the necessary number of data in a sample you have to be aware of the standard deviation (s), you have to provide the permissible estimation of errors (h), have to give the P% significance level or the likelihood of error. If we know the standard deviation in the unit of measurement of the data and the permissible estimation of errors are given in the same unit of measurement the sample size of the data can be calculated:

$$n = \frac{t_{P\%}^2 \cdot s^2}{h^2} \qquad (1)$$

n: number of items, t_p%: critical element of the „t”test, s: standard deviation, h: estimation of errors.

In case standard deviation is known in percentage (coefficient of variation) and the permissible estimation of errors is also given in percentage then the number of necessary elements can be defined by the following formula:

$$n = \frac{t_{P\%}^2 \cdot s\%^2}{h\%^2} \qquad (2)$$

n: number of items, t_p%: critical element of the „t”test, s%: standard deviation percentage (coefficient of variation) (%), h%: estimation of errors percentage (%).

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2. MATERIALS AND METHODS

One of the most important factors of landfill gas generation and composition is the climatic changes of the refuse dump. From the environmental parameters being aware of the external temperature, relative humidity, barometric pressure, level of rainfall and wind conditions is necessary. (Tab. 1.)

Table 1. Environmental conditions in the Hódmezővásárhely region

Title	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX	X.	XI.	XII.	Annual
Average temperature [°C]	1,6	0,1	5,7	11,1	16,5	19,7	22,1	21,3	17,3	11,1	5,2	0,5	10,8
Average rainfall [mm/month]	34	34	34	46	62	71	52	48	47	41	50	46	565
Mean evaporation [mm]	5	10	22	48	81	88	85	65	49	27	11	6	500
Wind direction frequency [%]	**É**	**ÉK**	**K**	**DK**	**D**	**DNY**	**NY**	**ÉNY**	**Windstille**				
	15,2	12,9	4,4	6,9	15,5	16	9,4	12,8	6,9				

During my tests in the cases of all gas wells I looked for relationships between the relative humidity values provided by the meteorological station and the methane content of the landfill gas recovered from the refuse dump. During the evaluation of data I considered it important to analyse the temperature, dew point and relative air humidity values. The values can be seen in Fig. 1.

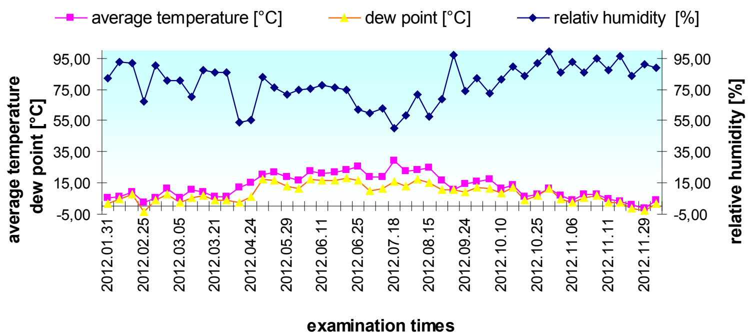

Figure 1. Average temperatures and relative air humidity values at measuring times

3. RESULTS

The results of the examination of the changes of relative air humidity and methane content of landfill gas can be found in Tab. 2 where it can be seen that minimum and maximum values change between 1-68% CH_4. The least favourable values were measured at the 2nd group (49,37%) and the most favourable was found at the 3rd group (51,59%). In case of appropriate controlling average methane content was 49,67% which fulfils the conditions of energy recovery regarding the total number of gas wells. From the numbers in Fig. 2. you can see that the in all cases, changes of relative air humidity values do not influence the methane content of landfill gas. The coefficient of variation in the case of 3rd group was CV%=23,59% as standard deviation was s=12,172% and the minimum and maximum values of methane content were between 13-66%. This can be caused by the most favorable methane content values in group 3 since the minimum and maximum values of group 5 are favorable but the increase of standard deviation and the decrease of average methane content modifies the value of coefficient of variation to CV%=28,64%. In the cases of 1st and 4th groups I measured 1% methane content in the examination period and because of that in the whole test range the value of the coefficient of variation is volatile, CV%=28,82%, and standard deviation is s=14,319% [3]

Table 2. Results of the relationship between relative humidity and methane content

Humidity group	Relative humidity [%]	n [db]	CH_4 mean [%]	Coefficient of variation CV% [%]	Std. deviation [%]	95% Confidence inteval for mean		Minimum [%]	Maximum [%]
						Lower bound	Upper bound		
1. group	50-60%	66	50,13	26,92	13,512	46,82	53,45	1	65
2. group	61-70%	55	49,37	29,72	14,677	45,4	53,33	6	66
3. group	71-80%	110	51,59	23,59	12,172	49,29	53,89	13	66
4. group	81-90%	176	47,85	32,47	15,541	45,54	50,16	1	68
5. group	>90%	110	50,52	28,64	14,469	47,79	53,26	17	68
	Total	517	49,67	28,82	14,319	48,43	50,9	1	68

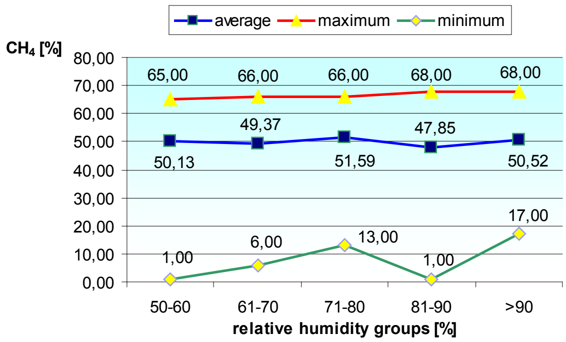

Figure 2. Relationship between relative humidity and methane content

Analysis of variance proved significant results between the group pairs, the level of significance is P<5% for the examined parameters. On the basis of homogeneity test the sample is homogeneous, I used the LSD test. I also carried out analysis between the groups, the results can be seen in Tab. 3. During the statistical process of the data between the 4th and 3rd groups I found 3,735% difference in methane content and P<5% significant difference [4]

Table 3. Results of the methane content difference and the group pairs

Humidity group	Relativ humidity [%]	1. group 50-60%	2. group 61-70%	3. group 71-80%	4. group 81-90%	5. group >90%
1. group	50-60%	-	ns	ns	ns	ns
2. group	61-70%	0,768	-	ns	ns	ns
3. group	71-80%	1,452	2,219	-	*	ns
4. group	81-90%	2,284	1,516	3,735	-	ns
5. group	>90%	0,388	1,155	1,064	2,671	-

For all of the gas wells I carried out a linear regressive examination taking both methane content changes and relative air humidity values into account (Fig. 3). The relationship between the methane content and the relative air humidity can be calculated by the following equation: $y=0,023x+51,478$, and $R^2=0,0004$. Coefficient of correlation is $r=0,002$ so we can conclude that the change of relative air humidity does not influence the methane content of landfill gas.

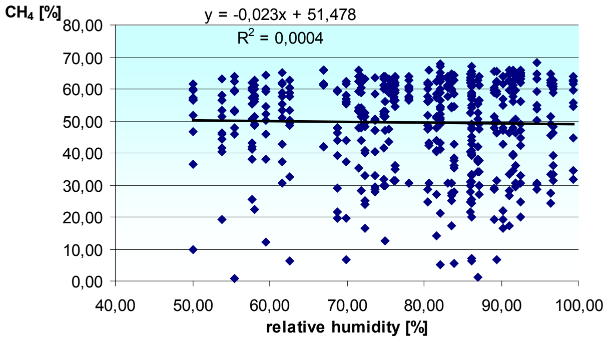

Figure 3. Change of the methane content with regard to relative air humidity

I looked for relationships between the characteristic methane content of gas wells and relative air humidity. Because of that I combined the 11 gas wells methane content values and their belonging relative air humidity values. Results can be found in Tab. 4. The average methane content values were between 32,53%-61,12%. 32.53%, the lowest value was found in the case of the 2nd gas well. In the cases of the other gas wells average methane content values are satisfactory with regards of energy recovery.

Table 4. Methane content values of each gas well with regard to relative air humidity

Humidity group	n [db]	1. gas well CH_4 [%]	2. gas well CH_4 [%]	3. gas well CH_4 [%]	4. gas well CH_4 [%]	5. gas well CH_4 [%]	6. gas well CH_4 [%]	7. gas well CH_4 [%]	8. gas well CH_4 [%]	9. gas well CH_4 [%]	10. gas well CH_4 [%]	11. gas well CH_4 [%]
1. group	6	49,52	36,83	44,32	57,97	54,07	60,77	53,15	58,13	27,08	52,48	57,17
2. group	5	54,66	39,16	49,56	49,84	51,62	60,16	56,58	55,1	35,98	46,62	43,76
3. group	10	52,89	33,25	50,78	58,22	55,07	60,89	51,32	60,59	40,06	52,52	51,86
4. group	16	43,34	22,01	41,54	47,6	48,17	60,23	51,97	58,96	55,62	55,47	41,46
5. group	10	42,12	42,75	35,58	55,19	52,46	63,45	52,12	59,9	55,87	58,45	37,86
Total	47	47,1	32,53	43,45	53,03	51,67	61,12	52,5	58,99	46,63	54,15	45,16

Analysis of variance proved significant results between the group pairs, in the level of significance is P<5% for the examined parameters. I carried out the Levenne homogeneity test and the results can be found in Tab. 4. At the 1st gas well analysis of variance did not prove significant results. In the case of the 2nd gas well in one case, between groups 5.-4., P<1% I found significant difference. In case of the 3rd gas well I carried out the statistical analysis between the group pairs and the results are the following: analysis of variance showed significant difference between group pairs 5.-3., P<1%, between group pairs 5.-2. And 4.-3. It was P<5%. At the 4th gas well between 4.-3. group pair significant difference is P<5%. At the 5th, 6th, 7th and 8th gas wells analysis of variance between group pairs proved significant results in only one case. At the 9th gas well analysis of variance proved significant results, which are the following: in the cases of group pairs 5.-2. and 5.-3. the significant difference is P<5%, in the case of group pairs 5.-1., 4.-1.,2,3 significant difference is P<1%. In the cases of the 10th and 11th gas wells by analysis of variance I found P<5% significant difference between group pairs 5.-2.

4. DISCUSSION

After data processing I found that at the refuse dump the changes of the methane content, recovered from the gas wells, are not influenced by relative air humidity as coefficient of correlation is r=0,02. The relationship between the relative air humidity and methane content changes of the landfill gas can be described with the equation: y=-0,023x+51.478, R^2=0,0004. Relative air humidity change in case of methane content by gas wells causes significant differences but the volume of this effect on the methane content of the total yield of landfill gas is not notable.

5. CONCLUSIONS

The landfill gas extraction was examined under operating conditions and it was found out which changes in the parameters caused the change of quantity and quality characteristics of the energetically utilized landfill gas. Overall, in a particular landfill, the meteorological parameters are always changing; the organic matter input parameters are characteristic of the region therefore the extraction efficiency can only be changed by the control of the exhaust capacity. Therefore, research has great importance in this area of research to show which landfill gas parameters are generated with the climatic parameters and organic matter intake. Both the existing and proposed landfill sites might use the results of my doctoral research for the best available landfill gas extraction and methane content.

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