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THE SIGNIFICANCE OF DIFFERENCES LEVEL POLLUTANT EMISSIONS COMBUSTION OF DIFFERENT FUELS

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ABSTRACT: This paper presents the results of determining the significance of levels emissions of sulfur dioxide (SO_2), carbon monoxide (CO) and nitrogen-oxide (NOx), during combustion of different kinds of fuel (brown coal, biomass and fuel oil) application the factorial analysis of variance. The paper used the average measured values of pollutants emission from local boiler houses in Zenica valley, which use the different kinds of fuel. You will find described the detailed data results, obtained by application of variance analysis in program SPSS V. 12.0 (Statistical Packet for Social Science).The presented results clearly show that there is a statistically significant difference in emission levels of SO_2 and CO during combustion of different types of fuels, while there is no statistically significant differences in levels of NOx emission.
KEYWORDS: fuel combustion, sulfur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NOx), emission pollutant

INTRODUCTION

Combustion of different fuels affects different levels of emissions of pollutants (SO_2, CO, NOx and dust particles, etc.) and different strain of ambient air quality. Monitoring of emissions from fuel combustion aims to control and reduce the concentration of certain pollutants and preservation of air quality [1, 2].

The level of emissions of these pollutants is different for different types of fuel combustion. This paper shows statistical analysis of the dependence of emissions from fuel and technical and technological characteristics of thermal power plants using factorial analysis of variance. Using analysis of variance tested the significance of differences of means of measured values for SO_2, CO, NOx. The method of analysis of variance is a general method for making conclusions about the multitude of parameters that relate to different populations. Significance of difference between levels of emissions is significant precisely in terms of air quality management in order to protect air quality and human health [3].

ANALYSIS OF VARIANCE FOR SIGNIFICANCE OF DIFFERENCES ASSESSMENT EMISSION LEVELS OF SO_2, CO AND NOx

Statistical analysis of data using analysis of variance using the SPSS statistical tools, the results obtained for SO_2 variable for different fuel types divided into groups (brown coal, extra light heating oil and wood biomass), which are shown in Tables 1, 2 and 3 and in Figure 1 [4].

Table 1. The results of processing the data dependencies of SO_2 emissions from fuel (Descriptives) [1, 4].

SO_2	N	mean	standard deviation	standard error	95% confidence interval		Minumum	Maximum
					Lower limit	Upper limit		
Brown coal	15	5283.57	2406.234	621.28	3951.04	6616.09	1171.54	9781.86
Fuel oil	3	136.37	80.45808	46.452	-63.49	336.24	43.50	184.91
Biomass	2	0.0000	0.00000	0.0000	0.0000	0.0000	0.00	0.00
Total	20	3983.13	3099.769	693.12	2532.39	5433.87	0.00	9781.86

Table 2. Results of analysis of variance (sums of squares, degrees of freedom associated probability) [1,4].

SO_2	sum of squares	df	mean square	F	Sig.
between groups	101490448.664	2	50745224.332	10.641	0.001
within the groups	810724360.354	17	4768966.844		
total	182562885.018	19			

Table 3. Results of post hoc test with significant differences between populations, Multiple Comparisons [1, 4].

(I) fuel	(J) fule	mean differences (I-J)	standard error	Sig.	95% confidence interval	
					Lower limit	Lower limit
Brown coal	Fuel oil	5147.19733(*)	1381.154	0.005	1604.0438	8690.3508
	Biomass	5283.57067(*)	1643.902	0.013	1066.3745	9500.7669
Fuel oil	Brown coal	-5147.19733(*)	1381.154	0.005	-8690.3508	-1604.0438
	Biomass	136.37333	1993.524	0.997	-4977.7282	5250.4749
Biomass	Brown coal	-5283.57067(*)	1643.902	0.013	-9500.7669	-1066.3745
	Fuel oil	-136.37333	1993.524	0.997	-5250.4749	4977.7282

In Figure 1 diagrams are shown with mean and ranges for different types of fuel (brown coal, extra light fuel oil and biomass) for SO_2 variable. From the diagram it can be observed a significant difference of means for the variable SO_2 (SO_2 levels) in the burning of brown coal in relation to SO_2 emissions during combustion of extra light fuel oil and biomass.

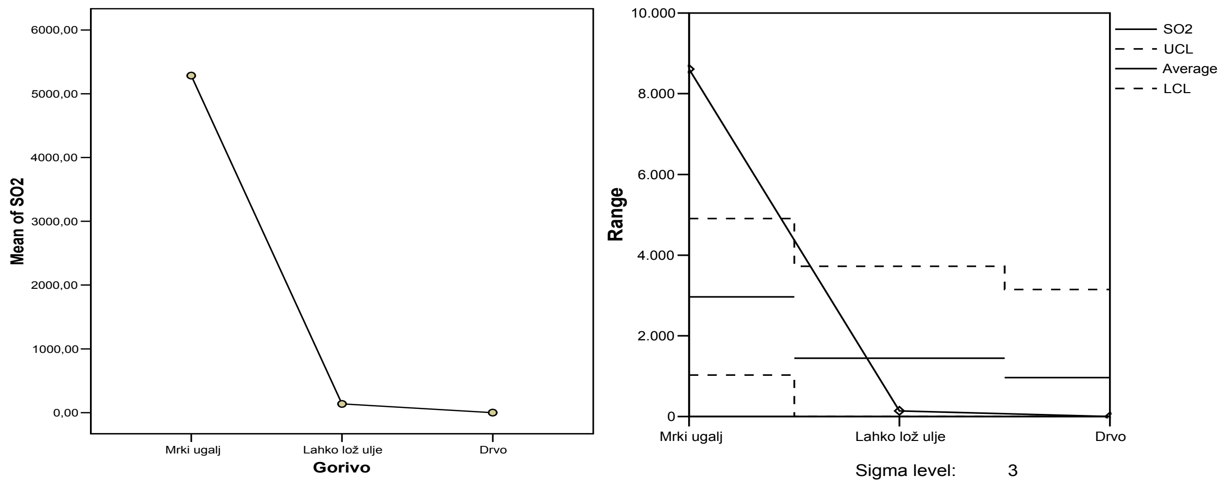

Figure 1. Diagrams of the mean and range of average emissions for different fuel types variable for SO_2 (Means Plots, Range)

*Post-hoc comparisons in Table 3. (Fields marked with an asterisk *) indicate that the mean and standard deviation of group 1-brown coal (M = 5283.57, SD = 2406.23) is significantly different from the mean and standard deviation of the group: 2-extra light heating oil (M = 136.37, SD = 80.45) and 3-biomass (M = 0.00, SD = 0.00). Group 2 (M = 136.37, SD = 80.45) is significantly different from group 1-brown coal (M = 5283.57, SD = 2406.23), but does not differ from group 3-biomass. Group 3-biomass (M = 0.00, SD = 0.00) are statistically significantly different from group 1-brown coal (M = 5283.57, SD = 2406.23).*

In Tables fourth to 6 give the results of processing one-way analysis of variance for variable CO for different populations of fuel divided into three groups (brown coal, extra light fuel oil and biomass) [1, 4].

Table 4. Results of data processing for the CO dependence of the fuel (Descriptives) [1].

CO	N	Means	Standard deviation	Standard error	95% confidence interval		Minimum	Maximum
					Lower limit	Lower limit		
Brown coal	15	2645.34	1235.9	319.1	1960.92	3329.7	70.11	5575.4
Fuel oil	3	41.18	31.4	18.1	-36.87	119.2	4.92	60.4
Biomass	2	22901.80	12934.4	9146.0	-93309.8	139113.4	13755.7	32047.8
Total	20	4280.36	7167.9	1602.8	925.65	7635.0	4.92	32047.8

Table 5. Results in analysis of variance (sums of squares, degrees of freedom associated probability) [1]

CO	Sum of squares	df	Mean square	F	Sig.
between groups	787527659.598	2	393763829.799	35.477	0.000
within the groups	188687019.920	17	11099236.466		
total	976214679.518	19			

Table 6.Results of post hoc test with significant differences between the populations (Multiple Comparisons) [1, 4].

(I) fuel	(J) Fuel	mean difference (I-J)	Standard error	Sig.	95% confidence interval	
					Lower limit	Lower limit
Brown coal	fuel oil	2604.16133	2107.058	0.449	-2801.1955	8009.5182
	Biomass	-20256.46367(*)	2507.900	0.000	-26690.1252	-13822.8022
Fuel oil	Brown coal	-2604.16133	2107.058	0.449	-8009.5182	2801.1955
	Biomass	-22860.62500(*)	3041.276	0.000	-30662.5856	-15058.6644
Biomass	Brown coal	20256.46367(*)	2507.900	0.000	13822.8022	26690.1252
	Fuel oil	22860.62500(*)	3041.276	0.000	15058.6644	30662.5856

From Table 5 can be seen that there is a statistically significant difference at p <0.05 level for the three fuel types [F (2, 17) = 35.47, p = 0.00]. Post-hoc comparisons in Table 6 show that the mean value for Group 1-brown coal (M = 2645.34, SD = 1235.90) are statistically significantly different from group 3-biomass (M = 22901.80, SD = 12934.47). Group 2-extra light heating oil (M = 41.18, SD = 31.42) is significantly different from group 3-biomass (M = 22901.80, SD = 12934.47), but not significantly different from group 1-brown coal. Group 3-biomass (M = 2290.80, SD = 12934.47) was statistically significantly different from group 1-brown coal (M = 2645.34, SD = 1235.90) and group 2 - extra light heating oil (M = 41.18, SD = 31.42).

In the Tables 7-9 give the results of processing one-way analysis of variance for the variable of NOx for different fuel types, divided into three groups (brown coal, extra light fuel oil and biomass).

Table 7. Results of processing data for the dependence of NOx emissions from fuel (Descriptives) [1]

NO_x	N	means	standard deviation	standard error	95% confidence interval		Minimum	Maximum
					Lower limit	Upper limit		
Brown coal	15	312.01	172.881	44.637	216.27	407.75	125.88	689.87
Fuel oil	3	142.70	63.902	36.894	-16.03	301.44	93.12	214.82
Biomass	2	53.08	13.604	9.620	-69.15	175.31	43.46	62.70
Total	20	260.72	176.854	39.545	177.95	343.49	43.46	689.87

Table 8. Results of analysis of variance (sums of squares, degrees of freedom associated probability) [1]

NO_x	Sum of squares	df	Mean square	F	Sig.
between groups	167484.811	2	83742.406	3.336	0.060
within the groups	426785.140	17	25105.008		
total	594269.951	19			

Table 9. Post hoc test results without significant differences between the established (Multiple Comparisons) [1]

(I) fuel	(J) fuel	mean difference (I-J)	standard error	Sig.	95% confidence interval	
					Lower limit	Upper limit
Brown coal	Fuel oil	169.31467	100.20980	0.238	-87.7592	426.3886
	Biomass	258.93800	119.27351	0.105	-47.0412	564.9172
Fuel oil	Brown coal	-169.31467	100.20980	0.238	-426.3886	87.7592
	Biomass	89.62333	144.64038	0.811	-281.4309	460.6776
Biomass	Brown coal	-258.93800	119.27351	0.105	-564.9172	47.0412
	Fuel oil	-89.62333	144.64038	0.811	-460.6776	281.4309

From Table 8 can be seen that there is no statistically significant differences at p <0.05 level for the three fuel types [F (2, 17) = 3.33, p = 0.06], because the associated probability p = 0.06 is greater than the threshold significance a = 0.05, respectively, it is evident that the value Fisher's test (F = 3.336), there are two degrees of freedom (D_{F1} = 2 D_{F2} = 17), and that the calculated probability p = 0.06 is greater than the threshold of significance a = 0.05, which confirms that the analyzed types of fuel there is no difference of means.

Significant difference levels of SO_2 and CO emissions for different fuel types, as the corresponding probability (p = 0.001, p = 0.00) lower than the threshold of significance a = 0.05. This means that significant differences exist not by chance but as a result of the systematic effects of certain factors. So, statistically significant difference exists in terms of higher levels of SO_2 emissions in the burning of brown coal, as compared to the other two groups of fuels (biomass, extra light heating oil), and higher levels of CO combustion of biomass as a result of the systematic effects of specific factors in relation to the other two types of fuel (brown coal, extra light heating oil). Post-hoc comparisons in Table 9 the values in column mean difference (Mean Difference) no marked symbol *star (*), which also means that there are no significant statistical difference levels of emissions that would be the result of systematic effects of certain factors, the observed types of fuel (1-brown coal, 2-extra light fuel oil, 3-biomass) in relation to the tested variable NOx (NOx emissions for different fuels).*

CONCLUSIONS

The conducted analysis showed that group 1-unfolding process of brown coal combustion in the boiler has a significant difference in the levels of SO_2 and the other two types of fuel (2 - extra light heating oil and 3-biomass). The reason for the increased emissions of SO_2 by combustion of brown coal is primarily high sulphur content in fuel (3.5-5%) and reduced combustion efficiency of the process of technical and technological characteristics of the boiler which burns brown coal. Group 3-biomass has a significant difference in the levels of CO emission compared to the other two types of fuel (1-brown coal, 2-extra light heating oil). The main reasons for the increased emissions of CO are bad conditions in the field of production of biomass combustion in boiler furnaces. Testing depending on NOx emissions for different fuel types has been found that the combustion of different fuels there is no significant difference between the level of NOx emissions, NOx emissions, because among other things depend more on the amount of combustion air and the temperature in the furnace. The osnvu this can be concluded that the type of fuel does not affect significantly the level of NOx emissions.

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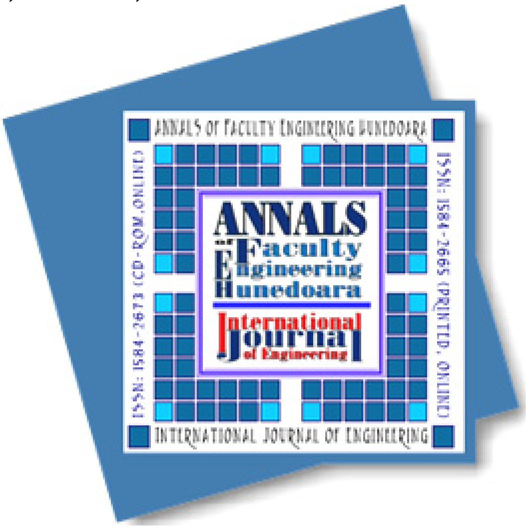

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