



Consiglio regionale della Calabria



Regione Calabria



Provincia di Reggio Calabria



Comune di Reggio Calabria



Camera di Commercio Reggio Calabria



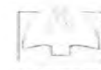
Corps Forestale dello Stato



UNACOMA Unione Nazionale Comunisti



EVAMA



COLDIRETTI



BIO VIVA

GESAF

ADAM



GRUPPO PIERALISI

EurAgEng



CIOSTA



XXXIII CIOSTA CIGR V Conference 2009



IUFRO



Unit 3.06.00

XXXIII CIOSTA CIGR V CONFERENCE 2009
TECHNOLOGY AND MANAGEMENT TO ENSURE
SUSTAINABLE AGRICULTURE, AGRO SYSTEMS,
FORESTRY AND SAFETY

WORKSHOP IUFRO
FORESTRY UTILIZATION IN MEDITERRANEAN COUNTRIES
WITH PARTICULARLY RESPECT TO SLOPING AREAS

Final Program

17-19 June
Reggio Calabria

8.2	Aghilnategh N., Hemmat A., Rezainejad Y., Sadeghi M.	Effect of Long-term Incorporation of Organic Manure on Physical and Mechanical Properties of a Silty Clay Loam Soil	1059
8.3	Ahlgren S., Baky A., Bernesson S., Nordberg A., Norén O., Hansson P.A.	Mineral nutrition Fertilisers Based on Renewable Resources - Implications for Alternative Fuels	1065
8.4	Alikhani S.S., Ebrahimi S.S., Shorafa M., Asgharzade A., Tavassoli A.	Assay of local petroleum hydrocarbons remediation in case of using of barley, 3 Bacillus treatments and also a combination of barley with three Bacillus species treatments	1071
8.5	Amirante R., Tamborrino A., Leone A., Girotto S.	Performance of compression type refrigerator using natural working fluid	1075
8.6	Amon T., et al.	Eu agro biogas project	1081
8.7	Balsari P., Giocelli F., Dinuccio E., Döhler H., Amon T.	Energy Recovery and Reduction of GHG Emission by the Coverage of a Digestate Storage Tank	1087
8.8	Berruto R., Busato P., Piccarolo P.	Economic and energetic analysis of crop systems management techniques by means of WEB application	1093
8.9	Blandini G., Manetto G., Mingrino F., Quattrone A.	Analysis of the Electrical Energy Requirements for a Cow-buffalo Farm	1099
8.10	Carvalho F. M., Oliveira G. H. H., Corrêa P. C., Carvalho N. M.	Acidity Influence over Oil Absorbance from Macaúba fruit (<i>Acrocomia aculeata</i>) pulp utilized for Biodiesel Production	1105
8.11	Chiumenti R., Chiumenti A., da Borso F., Limina S.	Feasibility Study of Centralized Plant for the Production of Energy and Reduction of Nitrogen from Livestock Farming Residues	1109
8.12	Döhler H., Niebaum A., Roth U., Amon T., Balsari P., Friedl G.	Greenhouse Gas Emissions and Mitigation costs in two European Biogas Plants	1115
8.13	Dubrovín V., Melnychuk M.	Agricultural & environmental engineering for Bioenergy Production	1121
8.14	Failla S., Restuccia A.	The use of grape marc for the production of energy: first assessments using a laboratory plant	1125
8.15	Ghorbani Z., Masoumi A. A., Hemmat A.	The Effect of Degree of Milling on Specific Energy Consumption of Alfalfa Chops	1131
8.16	Ghorbani Z., Masoumi A. A., Hemmat A.	Correlation between Specific Energy Consumption in Milling process and Some Physical and Mechanical Properties of Alfalfa Grind	1137
8.17	Gubiani R., Pergher G., Dell'Antonia D., Maroncelli D.	A Biomass District Heating System in Lusevera (Udine, Italy)	1143
8.18	Harsono S.S.	Coco-biofuel Production Based On High-Speed Centrifugation Non-Catalyst and It's Application For Improving Engine Performance of Fisherman Boat Using Direct Injection System	1149
8.19	Krampe P.	Improvement of the Efficiency of Agricultural Biogas Plants	1155
8.20	Lacour S., Dieudé-Fauvel E., Langle T., Galégués Y.	Numerical simulation tool to study fuel consumption during spreading	1161
8.21	Leonhartsberger C., Bauer A., Gerstl M., Pötsch E. M., Amon T.	Effect of the Intensity of Grassland Management on Biogas Production	1167
8.22	Moitzi G., Szalay T., Schüller M., Wagentrift H., Refenner K., Weingartmann H., Liebhart P.	Energy efficiency of wheat production in different soil tillage systems in the semi-arid region of Austria	1173
8.23	Riva G., Foppa Pedretti E., Toscano G., Corinaldesi F.	Model for the Forecasting of the Fusion Temperature of Biomass Ashes	1179

8.24	Riva G., Foppa Pedretti E., Toscano G.	Use of the Control Chart to Monitor the Biomasses quality in Power Plants	1185
8.25	Wong A., Ching D.L.K.	De-globalization of biofuel trade for social justice and cleaner environment	1191
8.26	Zenatti D. C., Gomes S. D., Fazolo A., Costanzi R. N., Gentilini A. L.	Evaluation Of The Nitrification Of The Tilapia Slugethhouse Effluent In The Sequential Batch Reactor With Immobilized Biomass	1197

TOPIC 9: FRUIT AND VEGETABLE CULTIVATION SYSTEMS

	Authors	Title	Page
9.1	Abazarian R., Azizi M., Shoor M., Arvin P.	Effects of Foliar Application of Zinc on Yield and Growth Analysis of Three Spinach Cultivars in Bojnourd (Iran) Area	1205
9.2	Al-Rashidi Mousul Saith.M.	The Effect of Landscape in some Soil properties and Wheat production (<i>Triticum asativum</i>)	1211
9.3	Azizi M., Arvin P.	Yield Difference and Radiation Use Efficiency of Spring Cultivars of the Oilseed Rape Species	1217
9.4	Biocca M., Conte E., Faraci A., Pochi D.	Evaluation of Losses of Imidacloprid from Conventional and Modified Pneumatic Drills for Maize	1223
9.5	Blandini G., Emma G., Failla S., Palumbo M., Virzi N.	Soil Conservation Technique of Minimum and No-Tillage for Durum Wheat Cultivation in Eastern Sicily	1229
9.6	Busato P., Allavena L., Berruto R., Piccarolo P.	A water saving technique for corn irrigation based on soil matrix potential scheduling and intermittent submersion	1235
9.7	Cavallo E.	Telehandler for mechanical pruning of hazelnuts	1241
9.8	Disciglio G., Depellegrino F.	Application of organic mineral fertilizers on processing tomato crop	1247
9.9	Eseghbeygi A., Basiryi M.	Influence of Electrohydrodynamic (EHD) on Drying Rate and Germination of Rapeseed (<i>Brassica napus</i> L.)	1253
9.10	Formato A., Scaglione G., Carillo M., Federico R.	A Prototype for the Soil Sterilizing	1259
9.11	Georgieva V., Moteva M., Kazandjiev V.	Contemporary Water Supply of Winter Wheat in Southern Bulgaria	1265
9.12	Giamella G., Zimbalatti G., Bernardi B.	Comparative tests on manual and mechanical pruning in spanish super intensive olive cultivation system	1271
9.13	Götz S., Bernhardt H.	Procedure comparison between cross compound and normal sowing taken with simultaneous consideration of work-economic, ecological and economic effects	1277
9.14	Jalali V.R., Homaei M.	Assessing of Salinity Models for Predicting Canola Response to Salinity under Rosette Stage	1283
9.15	Jalali V.R., Homaei M., Salman Taherizadeh	Investigations optimal use of saline soil and waters for sustainable canola production	1289
9.16	Keicher R., Schwarz H. P.	Documentation in Viticulture	1293
9.17	Khazaei J., Arabhosseini, A., Jafari S., Massah J.	Performance Evaluation of a Sunflower De-huller Machine	1299
9.18	Koca I., Hasbay Adil I., Karadeniz B., Yolcu H.	Production Technique and Some Physical-Chemical Properties Of Green Walnut Jam	1305

Use of the Control Chart to Monitor the Biomasses quality in Power Plants

G. Riva¹, E. Foppa Pedretti¹, and G. Toscano¹

¹ Polytechnic University of the Marche Region, SAIFET Dept., 60131 Ancona, Italy

g.toscano@univpm.it

Summary

In the last years the biomass market for energy production grew quickly as a consequence of the European policy in this sector. In order to satisfy this growing demand, various kinds of raw materials can be used as biofuel. In this context, power plants need to develop new methodologies to check the biomass quality and reduce the risk of failures. The Biomass Lab of Polytechnic University of Marche has applied a method named "control chart" to perform the control of some characteristics of the biomass fuels (moisture content, ash content, gross calorific value, element analysis, sulphur, chlorine and mineral element content). The method and its application to a specific case are described. The obtained results show the possibility of improving the quality of the energetic materials used in the power plants. In the specific case of this application, there is the possibility of reducing the variability of all the parameters by over 50% and to limit up to 40% the average values of some chemical elements, in particular heavy metals, and up to 20% the ash content.

Keywords: Biomass Characterization, Monitoring, Control Charts

Introduction

In Italy, about 257 MWe are generated by plants using solid biomass which would correspond to a biomass consumption of over 2.5 Mt/year. This estimation does not consider the biomass consumption of stoves and small boilers for which the estimation is more difficult. Considering the high level of consumption and the necessity to recover new supply sources, it is useful, in this context, to develop systems that control the fuel quality. The Technical Committee (CEN-TC 335 Solid biofuel) of the European Committee for Standardization (CEN) has been established for the standardization of solid biofuels, with reference to their specifications, quality and the method of sampling and analysis. Among the different developed standards, "CEN/TS 14961 Solid biofuels - Fuel specifications and classes" defines fuel quality classes and the relevant specifications. Nevertheless, the information provided by these methods is sometimes too broad, and the managers of the power plants need more sophisticated procedures. In order to implement a quality control system for solid biomass, biomass fuels used in two 10 MWe plants have been intensively monitored by the Biomass Lab of the Polytechnic University of Marche, over 500 sets of data have been used for a statistical survey, specifically aimed at the construction of "quality control charts". The control chart is useful to check that the values of different characteristics of individual samples are confined within pre-determined limits, when the sample values are distributed normally around the population average value. This tool, in general, is used to determine when a process is in a state of statistic control or not. In any production process, a certain amount of inherent or natural variability will always exist. This natural variability is the cumulative effect of many unavoidable causes and in the

framework of statistical quality control is often called "stable system of chance causes". A process that is operating with only chance causes of present variation - is said to be in statistical control. Other kinds of variability may occasionally be present in the output of a process and depending from external sources. Such variability is generally large when compared to the background noise and it usually represents an unacceptable level of process performance. In this application it has been considered the concept of "process" as the complex of the operations and phenomena of biomass provisioning for a power plant. The aim of the application is to define a simple method to identify changes in the process that, in the case of this application, is defined on the base of the variation of the fuel quality. Considering power plants that has a system of analytical monitoring and biomass outlining, the method supports the power plant operators, to identify and remove the variation sources of the material quality on the base of control limits. An example could be the exclusion of biomass suppliers that deliver products with certain parameters out of the values limit.

Material and methods

During a period of two-years, 537 biomass samples were collected in two power plants (A and B) of 10 MWe, located in Italy. Each sample has been analysed according to the CEN standards, in order to determine the following parameters: moisture content, ash content, gross calorific value, carbon, hydrogen, nitrogen, sulphur, chlorine and minor elements (Cd, Ni, Pb, Mn, Cu, Cr, As). In detail, 279 and 258 sets of data were relevant to the plant A and B (database A and B). The biomass fuel was of lignin-cellulose type - wood chips, generally produced from waste of wood or forests. All the statistical analyses were carried out by the software MINITAB®, using control chart tool. In particular, individual charts (IC) of individual observations were used - they allow process level tracking and special causes detecting (unusual occurrence that is not normally part of the process). Using IC tool, the Minitab defines graphs drawing the center line at the statistical average by default, the upper control limit (UCL), 3σ above the center line by default and lower control limit (LCL), 3σ below the center line by default. A point that plots outside of the control limits is interpreted like a process out of control - investigation and corrective action are required to find and eliminate the assignable causes or responsible reasons for this behavior. In other words, special cause results in a variation can be detected and controlled. A descriptive statistic and an IC processing were applied for each database and each analyzed parameter. Data found out of the control limits were eliminated from each database, producing a smaller database where a new descriptive statistic were applied. A comparison of these two databases was done, highlighting the theoretical improving on general quality of biomasses, from the application of control charts.

Results

Tables 2 and 3 show the results of the descriptive statistic and IC processing of data relevant to the power plant A. In particular, the control limits for each parameter are shown in the table 2, used to identify the special causes data. Comparison between the values, contained in the two tables, highlights that removing the special causes has produced a general reduction of the averages values, variable between 8% and 35% for the metal element, and about 14% for ash content (0,5% absolute). Moreover, it is possible to

notice the general reduction of the standard deviation of any parameter from 19% up to 81%, and the increasing of the GCV minimum value (8,7%). It is finally observed strong reduction of maximum values (in general over 50%), especially for metal element like Pb, Cu, As and also for ash content. As presented before, tables 4 and 5 show the results of the descriptive statistic and IC processing of data concerning the power plant B.

Table 2. Descriptive statistic and control limits of database from power plant A before IC processing.

PARAMETER	Unit	Mean	StDev	Minimum	Maximum	UCL	LCL
As	(mg/kg)	0.7	1.7	0.0	18.1	2.8	-1.4
C	(%)	49.22	2.01	41.80	62.40	53.57	44.86
Cd	(mg/kg)	0.4	0.3	0.0	3.7	0.8	-0.1
Cl	(%)	0.03	0.03	0.00	0.20	0.07	-0.01
Cr	(mg/kg)	2.6	4.2	0.0	31.8	10.2	-4.9
Cu	(mg/kg)	7.0	11.0	0.0	108.6	22.5	-8.4
H	(%)	6.18	0.31	4.83	7.48	6.84	5.52
Mn	(mg/kg)	56.9	38.8	0.0	294.6	150.1	-36.3
N	(%)	0.52	0.40	0.00	3.06	1.18	-0.15
Ni	(mg/kg)	2.42	2.14	0.00	16.45	6.90	-2.07
Pb	(mg/kg)	3.83	10.95	0.00	145.40	14.40	-6.70
S	(%)	0.03	0.03	0.00	0.24	0.08	-0.01
Moisture	(%)	43.7	7.0	16.3	62.2	58.0	29.5
Ash	(%)	3.6	4.5	0.2	57.1	10.0	-2.9
GCV	(kJ/kg)	19296	746	16494	24505	20699	17892

Table 3. Descriptive statistic of database from power plant A, after special causes removing.

PARAMETER	Unit	Mean	StDev	Minimum	Maximum
As	(mg/kg)	0.5	0.6	0.0	3.3
C	(%)	49.13	1.57	45.08	53.24
Cd	(mg/kg)	0.3	0.2	0.0	0.8
Cl	(%)	0.02	0.02	0.00	0.07
Cr	(mg/kg)	1.8	2.0	0.0	10.2
Cu	(mg/kg)	5.1	4.2	0.0	22.3
H	(%)	6.20	0.24	5.57	6.74
Mn	(mg/kg)	52.2	28.9	0.0	153.2
N	(%)	0.44	0.25	0.00	1.13
Ni	(mg/kg)	2.01	1.29	0.00	6.72
Pb	(mg/kg)	2.54	2.09	0.00	13.08
S	(%)	0.03	0.02	0.00	0.08
Moisture	(%)	44.4	5.7	30.0	57.9
Ash	(%)	3.1	1.7	0.2	9.2
GCV	(kJ/kg)	19318	466	17927	20459

The table 4 illustrated the control limits related to each parameter used to identify the special causes data. The comparison between the value of the two tables highlights that removing the special causes has produced a higher general averages reduction included from 12,5% up to 40% for the metal element, and about 19% for the ash content. It is also possible to notice the general reduction of the standard deviation for any parameters from

8% up to 70%. It is finally observed, an important reduction of maximum values (in general over 50%), especially for metal elements like Pb, Cu and Cd. Some observations can be made for the comparison of the control limits of the two powers plant. In general, excepting As, the control limits of the plant A are more restrictive in comparison to the plant B. In average differences are between 20% and 30%. Some metals, like Cr and Mn, show an important control limit differences (more than 40%), and particularly high is the case of the Pb, up to 74%. Moreover, important differences have been also found in the ash content (44%), unlike the parameters C and H, moisture content and gross calorific value - whose values are similar.

Table 4. Descriptive statistic and control limits of database from power plant B before IC processing.

PARAMETER	Unit	Mean	StDev	Minimum	Maximum	UCL	LCL
As	(mg/kg)	0.5	0.9	0.0	9.5	2.0	-1.0
C	(%)	48.22	3.46	31.92	68.87	56.06	40.39
Cd	(mg/kg)	0.4	0.5	0.0	4.0	1.2	-0.4
Cl	(%)	0.0	0.0	0.0	0.3	0.1	0.0
Cr	(mg/kg)	4.3	6.8	0.1	49.1	17.4	-8.8
Cu	(mg/kg)	10.3	18.2	1.6	226.0	35.4	-14.9
H	(%)	6.14	0.46	4.22	9.01	7.26	5.02
Mn	(mg/kg)	77.1	103.2	6.8	1252.5	250.0	-1.0
N	(%)	0.6	0.4	0.0	2.7	1.6	-0.4
Ni	(mg/kg)	2.7	3.4	0.0	32.0	8.4	-3.1
Pb	(mg/kg)	13.3	25.7	0.0	293.7	56.0	-29.4
S	(%)	0.0	0.0	0.0	0.5	0.1	0.0
Moisture	(%)	37.5	10.6	7.7	56.0	65.9	-9.1
Ash	(%)	5.9	5.3	1.0	37.1	18.0	-6.3
GCV	(kJ/kg)	18883	1183	10301	23200	21456	16311

Table 5. Descriptive statistic of database from power plant B, after special causes removing.

PARAMETER	Unit	Mean	StDev	Minimum	Maximum
As	(mg/kg)	0.3	0.5	0.0	3.3
C	(%)	48.73	2.30	31.92	55.96
Cd	(mg/kg)	0.3	0.2	0.0	1.1
Cl	(%)	0.0	0.0	0.0	0.1
Cr	(mg/kg)	2.7	3.5	0.1	23.3
Cu	(mg/kg)	6.6	4.2	1.6	25.7
H	(%)	6.19	0.30	4.37	6.92
Mn	(mg/kg)	57.2	34.1	8.7	206.0
N	(%)	0.5	0.3	0.0	1.4
Ni	(mg/kg)	1.9	1.2	0.2	11.0
Pb	(mg/kg)	7.9	8.6	0.2	54.8
S	(%)	0.0	0.0	0.0	0.1
Moisture	(%)	39.1	9.8	12.6	56.0
Ash	(%)	4.8	3.7	1.0	32.9
GCV	(kJ/kg)	19069	998	10301	23200

Discussion

The application of control chart on physical-chemical biomasses data has permitted to determine reference values for every power plant, defining when the physical-chemical characteristics of biofuel are considered as having a good performance. Through UCL and LCL values, it may be possible to classify the biomass acquired on the owner biomasses market and to make management decisions. It could be also the possibility of thinking of monitoring the general information of the samples that do not respect the control limits established, and to investigate on the origin, on the type of supplier and on other aspects of the acquisition and material delivery chain. The power plants, managing information on the biomasses received, can verify, for instance, whether there are suppliers that have the tendency to not respect the values of the control limits and, thus, eliminate the provisioning of the biomasses, improving the quality of the material. The definition of the control limits can depend on the type of biomasses market, from where the power plant acquires the product. It is possible to observe a lower UCL values for power plant A compared to power plant B. The differences are bigger for parameters linked to impurities, such as ash content and chemical element like Cu and Pb, but lower in the case of gross calorific value and moisture content. In the specific case of the two power plants, the consequential potential benefit from the application of the control charts has been underlined by the comparison of the descriptive statistics of the databases with and without the considered values "anomalous" (special causes). It is highlighted an important improvement of the materials quality, especially in terms of ash and metal contents and a reduction of the parameters variability. However, it is evident how the parameters considered as materials control can be diversified and selected from the operators on the base of specific peculiarities and demands of the operational context.

References

- Botta G., Brignoli V., Alberti M., Riva G., Toscano G., Scrosta V., 2003. Analisi delle iniziative per la produzione di energie elettrica da biomasse agro-industriali in Italia. IV Convegno Nazionale Utilizzazione Termica dei Rifiuti - Abano Terme.
- Pinelli G., Zerlia T., 2005. La caratterizzazione energetica e merceologica delle biomasse vegetali. La Rivista dei Combustibili, Vol. 59 (1).
- Montgomery D., 2005. Introduction to statistical quality control, Wiley & Sons, Fifth edition, page. 741.
- Oakland J., 2003. Statistical process control, Butterworth-Heinemann, Fifth edition, page. 445.