

REFERENCES

- Angelidaki, I., Ahring, B. K. (2000). Methods for increasing the biogas potential from the recalcitrant organic matter contained in manure. *WaterSci. Tech.*, 41, 189-194
- Biogas digest volume 1-Biogas Basics, Information and Advisory Service on Appropriate Technology, 2001
- Butlin, K. R., S. R. Selwyn, and D. S. Waverley. (1956), Sulfide Production from Sulfate-Enriched Sewage Sludges. *J. Appl. Bacteriol.* 19:3-15.
- Eder B. and Schulz H., (2006), *Biogas Praxis [in German]*, 3rd Edition, ISBN 3-936896-13-5 ökobuchVerlag, Staufen, Germany.
- Emiliano Bruni, (2010), Improved Anaerobic Digestion of Energy Crops and Agricultural Residues
- Gaspar, M.; Kalman, G.; Reczey, K.,(2007), Corn fiber as a raw material for hemicellulose and ethanol production. *Process Biochem*,42, 1135-1139.
- HuoqingGe, Paul D. Jensen, Damien J. Batstone, (2010),Pre-treatment mechanisms during thermophilic–mesophilic temperature phased anaerobic digestion of primary sludge, *Water Research* 44 123 – 130
- IvetFerrer, (2008), Study of the process parameters on thermophilic anaerobic digestion of sewage sludge, evaluation of thermal sludge pre-treatment and overall energetic assessment
- Angelidaki, M. Alves, D. Bolzonella, L. Borzacconi, J. L. Campos,A. J. Guwy, S. Kalyuzhnyi, P. Jenicek and J. B. van Lier, (2009),“Defining the bio-methane potential (BMP) of solid organic wastes and energy crops: a proposed protocol for batchassays”, *Water science & technology*
- ITDG, (2003),” Boigas technology utilization in Sri Lanka
- JiraphonSrisertpol, PrasitSrinakorn, AdevirodKheawnak and Kontorn Chamniprasart, (2010), “Mathematical Modeling and Parameters Estimation of an Anaerobic Digestion of Shrimpp Culture Pond Sediment in a Biogas Process
- J.A. Álvarez, L. Otero, J.M. Lema, (2010), A methodology for optimizing feed composition for anaerobic co-digestion of agro-industrial wastes
- Kularatna, M. A. D. I. C. (2010). Development of a pilot scale biogas plant to utilize bio methane as a transport fuel. Department of Chemical & Process Engineering.Moratuwa, University of Moratuwa.Master of Science Degree.

Konard Koch, Manfred Lubken, Tito Gehring, Marc Wichern, Harald Horn, (2010),” Biogas from grass silage- Measurements and modeling with ADMI”, *Bioresource Technology*

Koster, I. W., (1986),”Characteristics of the ph-influenced adaptation of methanogenic sludge to ammonium toxicity.” *Journal of Chemical Technology & Biotechnology* 36(10): 445-455.

Kayhanian, M., (1994),”Performance of a high-solids anaerobic digestion process under various ammonia concentrations.” *Journal of Chemical Technology & Biotechnology* 59(4): 349-352.

Kroiss, H., and F. P. Wabnegg.,(1983), Sulfide toxicity with anaerobic wastewater treatment, p. 72-85. In W. J. van der Brink (ed.), *Proceedings of the European*

Kaparaju, P., &Felby, C. (2010), Characterization of lignin during oxydative and hydrothermal pre-treatment processes of wheat straw and corn stover.*Bioresour. Technol.*, 101, 3175-3181

Mohammad J. Taherzadeh andKeikhosroKarimi,Pretreatment of Lignocellulosic Wastes to Improve Ethanol and Biogas Production: A Review,*International Journal of Molecular Sciences*, 9, 1621-1651

Michael Schön, (2009), Numerical modeling of Anaerobic digestion processes in agricultural biogas plants



Ofoefule A. U. , Onyeoziri M. C. and Uzodinma E. O.; (2011), Comparative study of biogas production from chemically-treated powdered and un-powdered rice husks, *Journal of Environmental Chemistry and Eco-toxicology* Vol. 3(4), pp. 75-79

Ruihong Zhang”, Zhiqin Zhang, (1998), Biogasification of rice straw with an anaerobic-phased solids digester system, *Bioresource Technology* 68, 235-245

S.A.S. Perera, (2001),”Is anaerobic digestion of municipal garbage to produce biogas economically feasible

S.A.S. Perera, (2008), “Delta-D initiated micro organic digestion of saw dust into organic fertilizer-A technically, economically and environmentally feasible solution to the saw dust problem in Sri Lanka, ”*Engineers-Vol.xxxi*, pp 50-65.

Sun, Y., & Cheng, J. (2002). Hydrolysis of lignocellulosic materials for ethanol production: a review. *Bioresour. Technol.*, 83, 1-11.

Saulnier, L., Marot, C., Chiliad, E., &Thibauld, J. F. (1995).Cell wallpolysaccharide interactions in maize bran.*Carbohydr.Polym.*, 26, 279-287

Symposium on Anaerobic Wastewater Treatment (AWWT). AWWT Symposium Secretariat, TNO Corporate Communication Department, The Hague, Netherlands.

Speece, R. E., and G. F. Parkin., (1983), The response of methane bacteria to toxicity, p. 23-35. In R. L. Wentworth, D. A. Stafford, B. I. Wheatley, W. E. Edelmann, G. Lettinga, Y. Minoda, P. Mulas del Pozo, E. J. Nyns, F. G. Pohland, J. F. Rees, L. van den Berg, W. Verstraete, and R. F. Ward (ed.), Proceedings of the 3rd International Symposium on Anaerobic Digestion. Evans and Faulkner, Inc., Watertown, Mass

Teodorita Al Seadi, DominikRutz, Heinz Prassl, Michael Köttner, Tobias Finsterwalder,Silke Volk, Rainer Janssen,(2008),Biogas Handbook

Urmila Gupta Phutela, NidhiSahni and Sarbjit Singh Sooch,(2011) Fungal degradation of paddy straw for enhancing biogas production, Indian Journal of Science and Technology, Vol. 4 No. 6, pp 660-665

Wan Azlina Wan Ab Karim Ghani, (2009),”Preliminary Study on Biogas Production of Biogas from MSW Leachate”,

Winfrey, M. R., and J. G. Zeikus. (1977), Effect of sulfate on carbon and electron flow during microbial methanogenesis in freshwater sediments. *Appl. Environ. Microbiol.* 33:275-281

Yen, H.-W andBrune, D. E. (2007). "Anaerobic co-digestion of algal sludge and waste paper to produce methane." *Bioresource Technology* 98(1): 130-134.

Yanfeng He, YunzhiPang, YanpingLiu, XiujinLiandKuisheng Wang, (2008), Physicochemical Characterization of Rice Straw Pretreated with Sodium Hydroxide in the Solid State for Enhancing Biogas Production, *Energy & Fuels*, 22, 2775–2781

Zehnder, A., &Stumm, W., (1988), Geochemistry and biogeochemistry of anaerobic habitats. I A. Zehnder, *Biology of anaerobic microorganisms* (s.872).

Zhang, R.H.; Zhang, Z.Q, (1999), Biogasification of rice straw with an anaerobic-phased solids digester system. *Bioresource Technol.*, 68, 235-245

Zhao, X.; Zhang, L.; Liu, D. ,(2007), Comparative study on chemical pretreatment methods for improving enzymatic digestibility of Crofton weed stem. *Bioresource Technol.*99, 3729-3736

Zaid Isa, StephaneGrusenmeyer, And Willy Verstraete,(1985), Sulfate Reduction Relative to Methane Production in High-Rate Anaerobic Digestion: Technical Aspects

APPENDICES

APPENDIX A

LINDEL INDUSTRIAL LABORATORIES LTD.
Pattiwila Road, Sapugaskanda,
Makola, Sri Lanka.

Tel : +94 11 2401675
Fax : +94 11 2401675
+94 11 2400321

Email : lill@itmin.net
Web : www.lindel.com

ANALYSIS REPORT

REFERENCE NO : CS/12/054, CS/12/055, CS/12/056, CS/12/057,
CS/12/058, CS/12/059, CS/12/060, CS/12/061,
CS/12/062, CS/12/063, CS/12/064.

CLIENT : Mr: Sudam Weeranayaka.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



ISO/ IEC: 17025
TL 006- 01

20th March 2012.

Pg. 01 of 03

A handwritten signature in blue ink, appearing to be 'JD' or similar initials.

QUALITY IS OUR BUSINESS

LINDEL INDUSTRIAL LABORATORIES LIMITED.

ANALYSIS REPORT

REFERENCE NO : CS/12/054, CS/12/055, CS/12/056, CS/12/057,
CS/12/058, CS/12/059, CS/12/060, CS/12/061,
CS/12/062, CS/12/063, CS/12/064.

CLIENT : Mr: Sudam Weeranayaka.

SPECIMEN : Slurry Samples

PARTICULARS OF THE SPECIMEN : Approx. 250 ml samples in each plastic container & named as follows:
A1, A2, A3, A4, A5, B1, B2, B3, B4, C1 & C2

Appearance (Condition) :- Dark Green Slurry Samples.

Sampling Carried Out By :- The Client

Reception at the Laboratory :- 24/02/2012 @ 10.30 a.m.

Date of Issue :- 20/03/2012

TEST REQUIRED : UniveRequested by the client, mail dated 27th February 2012.



Electronic Theses & Dissertations
www.lib.mrt.ac.lk

METHOD OF ANALYSIS : ASTM , ISO & SLS

CONDITIONS :

- The results given in this report relate only to the same sample tested.
- This report shall not be reproduced except in full without the written approval of the laboratory.

LILL Continuation Sheet.....

Sample Ref	pH*	TS (mg/L)	TVS (mg/L)	COD* (mg/kg)	C:N ratio
A1(CS/12/054)	6.81	8.4 X 10 ⁴	6.0 X 10 ⁴	7.60 X 10 ⁴	-
A2(CS/12/055)	6.5	7.9 X 10 ⁴	6.0 X 10 ⁴	6.10 X 10 ⁴	-
A3(CS/12/056)	6.77	10.3 X 10 ⁴	8.0 X 10 ⁴	7.38 X 10 ⁴	-
A4(CS/12/057)	6.61	12.2 X 10 ⁴	10.0 X 10 ⁴	7.43 X 10 ⁴	-
A5(CS/12/058)	6.97	10.2 X 10 ⁴	6.2 X 10 ⁴	6.31 X 10 ⁴	20.4
B1(CS/12/059)	6.62	8.2 X 10 ⁴	5.6 X 10 ⁴	6.92 X 10 ⁴	-
B2(CS/12/060)	6.95	6.6 X 10 ⁴	4.9 X 10 ⁴	4.59 X 10 ⁴	-
B3(CS/12/061)	6.99	5.8 X 10 ⁴	4.5 X 10 ⁴	4.54 X 10 ⁴	-
B4(CS/12/062)	6.64	5.8 X 10 ⁴	4.3 X 10 ⁴	4.69 X 10 ⁴	-
C1(CS/12/063)	6.84	11.8 X 10 ⁴	10.1 X 10 ⁴	6.39 X 10 ⁴	54.7
C2(CS/12/064)	6.95	5.0 X 10 ⁴	3.6 X 10 ⁴	4.46 X 10 ⁴	30.0

Note :

Parameter	Test Method
TS (Total Solids)	ASTM 2005 - E 1756-01
TVS (Total Volatile Solids)	ASTM 2005 - E 1755-01
COD*(Chemical Oxygen Demand)	ASTM 2005 - D1252-00
Organic Carbon for C:N Ratio	SLS 1246 : 2003 - Weekly Black Method
Organic Nitrogen for C:N Ratio	ISO 5663 : 1984

* Accredited Tests



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



ISO/IEC: 17025
TL 006-01

S.U.P. PANAWENNAGE

Technical & Quality Manager

LINDEL INDUSTRIAL LABORATORIES LTD.

20th March 2012

Heshan Gunasekara

Senior Analytical Chemist

Pg. 03 of 03

APPENDIX B

LINDEL INDUSTRIAL LABORATORIES LTD.

Pattiwila Road, Sapugaskanda,
Makola, Sri Lanka.

Tel : +94 11 2401675
Fax : +94 11 2401675
+94 11 2400321

Email : lil@itmin.net
Web : www.lindel.com

ANALYSIS REPORT

REFERENCE NO : CS/12/079, CS/12/080, CS/12/081, CS/12/082,
CS/12/083, CS/12/084, CS/12/085, CS/12/086,
CS/12/087.

CLIENT : Mr: Sudam Weeranayaka.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



ISO/IEC: 17025
TL 006-01

20th March 2012.

Pg. 01 of 03

A handwritten signature in blue ink, appearing to be 'A' or similar.

UNIVERSITY OF MORATUWA

LINDEL INDUSTRIAL LABORATORIES LIMITED.

ANALYSIS REPORT

REFERENCE NO : CS/12/079, CS/12/080, CS/12/081, CS/12/082,
CS/12/083, CS/12/084, CS/12/085, CS/12/086,
CS/12/087.

CLIENT : Mr: Sudam Weeranayaka.

SPECIMEN : Slurry Samples

PARTICULARS OF THE SPECIMEN : Approx. 250 ml samples in each plastic container & named as follows;
A1, A2, A3, A4, A5, B1, B2, B3 & B4.

Appearance (Condition) :- Dark Green Slurry Samples.

Sampling Carried Out By :- The Client

Reception at the Laboratory :- 08/03/2012 @ 12.30 a.m.

Date of Issue :- 20/03/2012

TEST REQUIRED  University of Moratuwa, Sri Lanka
Requested by the client, mail dated 27th February 2012.
www.lib.mrt.ac.lk

METHOD OF ANALYSIS : ASTM , ISO & SLS

CONDITIONS :

- The results given in this report relate only to the same sample tested.
- This report shall not be reproduced except in full without the written approval of the laboratory.



LILL Continuation Sheet.....

Sample ref	TS (mg/L)	TVS (mg/L)	COD* (mg/L)
A1 (CS/12/079)	5.48 X 10 ⁴	3.11 X 10 ⁴	4.9X 10 ⁴
A2 (CS/12/080)	5.32 X 10 ⁴	3.48X 10 ⁴	3.75 X 10 ⁴
A3 (CS/12/081)	8.39X 10 ⁴	6.86X 10 ⁴	5.57 X 10 ⁴
A4 (CS/12/082)	10.85 X 10 ⁴	9.24X 10 ⁴	5.56 X 10 ⁴
A5 (CS/12/083)	7.16 X 10 ⁴	3.45X 10 ⁴	5.56 X 10 ⁴
B1 (CS/12/084)	7.52X 10 ⁴	5.3 X 10 ⁴	6.14 X 10 ⁴
B2 (CS/12/085)	6.49X 10 ⁴	4.84 X 10 ⁴	4.05 X 10 ⁴
B3 (CS/12/086)	5.78 X 10 ⁴	4.46 X 10 ⁴	4.1 X 10 ⁴
B4 (CS/12/087)	5.75 X 10 ⁴	4.23X 10 ⁴	4.3 X 10 ⁴

Note :

Parameter	Test Method
TS (Total Solids)	ASTM 2005 - E 1756-01
TVS (Total Volatile Solids)	ASTM 2005 - E 1755-01
COD*(Chemical Oxygen Demand)	ASTM 2005 - D1252-00

* Accredited Tests



ISO/ IEC: 17025
TL 006- 01



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



S.U.P. PANAWENNAGE

Technical & Quality Manager

LINDEL INDUSTRIAL LABORATORIES LTD.

20th March 2012



Heshan Gunasekara

Senior Analytical Chemist

Pg. 03 of 03

CS/12/042	Chemical sample Sample 12	Nitrate as NO ₃ - 1.9 g/kg	UV screen method
		Sulphate as SO ₄ - 97.8 g/kg	Turbidity metric method
		Chloride as Cl -< 100mg/kg	Argentometric
			Above 03 method from APHA 21 st Edition

Note :

AAS = Atomic Absorption Spectrophotometer

MJ/kg = Mega joule per kilogram

mg/kg = Milgram per kilogram



S.U.P. Panawennage
Technical & Quality Manager
LINDEL INDUSTRIAL LABORATORIES LTD.
13th March 2012.



Heshan Gunasekara
Senior Analytical Chemist



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk