ETC 237/16/234

**TECHNICAL REPORT
ON
EVALUATION OF
COMPOST GENERATED FROM FOOD WASTE**

For

**S.E.N. Tech. Sdn. Bhd.
No. 8, Jalan Margosa SD 10/4B,
Bandar Sri Damansara,
52200 Kuala Lumpur.**

Prepared by

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EXECUTIVE SUMMARY

Preamble

S.E.N. Tech. Sdn. Bhd. had approached SIRIM Environmental & Energy Technology Centre (SIRIM) to evaluate the performance of a composting unit (Biomate On-site Composting Unit Model Bio-Mate BM – 300S) that is able to produce quality compost from restaurant food waste.

SIRIM proposed three criteria for the performance evaluation:

i. Evaluation of the compost material against an established standard.
ii. Evaluation of the condensate produced from the composting unit in respect of its nutritional and polluting properties.
iii. Evaluation of the composting conditions based on site measurement of the oxygen and carbon dioxide content, as well as temperature of the composting mass.

The most appropriate standard available for evaluating the quality of the compost material was the Australian Standard AS 4454 – 1997 on Composts, soil conditioners and mulches. Since there was no comparable local, foreign or international standard of similar topic, AS 4454 was used almost in totality.

Trial run of the composting unit was carried out at a restaurant in Klang. From the menu provided by the restaurant, the food waste would contain a high content of meat, i.e. protein-based waste. The food waste is mixed with filler materials such as rice husk and wood chips.

The production of the final compost material is a three-stage process, beginning with composting, grinding and sieving of the composted material. The retention time of the composting mass is seven days at 80°C with a continuous fresh flow of air through the composting unit. Heat is electrically generated and air injection is obtained through a suction system.

The company would prefer the evaluation of the final composted material instead of the raw compost.

Two SIRIM staff carried out a sampling session and site measurement of the composting unit on 10th October 2001. The final compost, in the form ready for land application was analysed for its chemical, physicochemical, pathogenic and phytotoxicity characteristics.

Findings

Compost product

Depending on the form of application, the compost generated from the composting unit did fulfill the requirements stated in AS 4454. In other words, it is suitable for use as a soil conditioner or as mulches provided the specific application rates are mentioned when certain sensitive species of plants are exposed to the compost.

The total nitrogen content of the compost was high but the percentage that is available as the soluble nitrate-nitrogen is relatively low. The high organic nitrogen concentration as compared to the degraded forms of ammoniacal and nitrate nitrogen may infer the microbial degradation has not been efficient.

Iron, manganese and zinc, although present in small concentrations were still higher than the other metals such as lead, boron, nickel and chromium that were found at trace levels. The higher concentration of iron, manganese and zinc could imply some form of corrosion has taken place, either within the composting unit or utensils used in the preparation of food in the restaurant. It may be a good idea to further investigate this occurrence and if practical, to coat the internal wall of the composting unit with anti-corrosion paint.

Condensate

The condensate that was discharged from the condenser of the composting unit was found to contain concentrations of BOD and COD that exceeded the limits established under the Environmental Quality Act (Sewage and Industrial Effluents) Regulations 1979.

As the volume of condensate that was discharged per day into the public waterways is small, the impact of the organic polluting load at ~ 0.2 kg/day BOD was very much lower than the regulatory limit of 60 kg/day BOD. According to the Environmental Quality Act Regulations, the condensate can be discharged without any treatment.

The ammoniacal nitrogen content in the condensate was high, indicative again of the lower composting efficiency and also a temperature within the composting mass that is too hot at ~ 80°C. This temperature could have given rise to rapid loss of ammoniacal nitrogen from the composting mass.

Composting unit

Gaseous measurement for oxygen and carbon dioxide at the core of the composting mass showed an aerobic condition existed within the composting unit. In fact there was only a small depletion of the oxygen content from the normal atmospheric value while the concentration of carbon dioxide was also slightly higher at ~ 0.6%.

The high oxygen content is due to the continual suction of fresh and removal of spent air through the composting unit. This condition should in principle be favourable for microbial activity. As mentioned earlier, the high concentration of organic nitrogen infers its microbial degradation to ammoniacal-nitrogen and eventual oxidation to nitrate-nitrogen is not efficient.

The low microbial activity could have been caused by the high temperature of the composting mass that is above the recommended literature values ranging from 55 - 70°C.

General comments

The composting unit that is evaluated in this project is not typical of the natural composting process where heat is generated through microbial activity. The external heating source could have been introduced to enhance composting and destruction of potential pathogens. Good aeration is also brought about by drawing in the atmospheric air through a suction pump.

Visually, the compost material looked presentable and suitable for land application. The short retention time needed to compost chunky food waste material to fine powdery compost is an attractive recycling option. The concept ties in very well with current emphasis on maximizing resources and waste minimization. It will also contribute to the solid waste management problem in the country. The composting unit is also a suitably size, easy to operate and compact for it to be conveniently placed at most eateries.

However, there can be further improvement to the composting process through modification of the *modus operandi* (parameters such as temperature) and possibly the composition of the food waste. Through further optimization, the composting unit will definitely provide a viable option to the disposal of restaurant food waste as solid waste or garbage.

INFERENCE FROM LABORATORY ANALYSIS, SITE MEASUREMENTS & OTHER RELEVANT TECHNICAL INFORMATION

1. Introduction

SIRIM Environmental and Energy Technology Centre was commissioned by S.E.N. Tech. Sdn. Bhd. to undertake an on-site sampling and analysis of compost and condensate generated from a food waste composting unit (Biomate On-site Composting Unit Model Bio-Mate BM – 300S). According to the company, the composter is set to operate at 80 °C and in aerobic condition through mechanical suction of air via an inlet tube. The retention time was also set at about seven days, after which the composted material is ground and sieved.

Grab samples of compost and condensate were collected on 10th of October 2001 by SIRIM personnel and tested to assess their compliance with Australian Standard AS4454-Soil Conditioners, Composts and Mulches. The product for the composting unit does fulfill the compost requirement of AS4454 where the compost would have been subjected to at least three consecutive days of composting at $\geq$ 55 °C to ensure reduction of level of pathogens.

The range of analysis cover heavy metals, total kjeldahl nitrogen, ammonical-nitrogen, pH, electrical conductivity, plant toxicity and pathogenic evaluation with reference to the presence of *Salmonella, Escherichia Coli, Enterobacteria, Staphylococcus Aureus and Pseudomonas Aeruginosa.*

Condensate generated from the composting unit was collected and characterised for heavy metals, BOD_5, COD, total kjeldahl nitrogen, ammonical nitrogen, pH and electrical conductivity. The analysis of condensate was undertaken to determine its nutrient content as well as pollutant load. Gaseous measurements for oxygen and carbon dioxide were conducted to determine the existence of an aerobic condition during composting.

2. Chemical, Physical and Microbiological Properties

The chemical composition of the compost was evaluated in terms of its major and minor constituents.

a) Major Chemical Constituents

The results in Table 1 are summarised from 'RESULTS SUMMARY' R195/01 attached as Appendix C of this report.

The compost sample contained about 11% moisture, a value which is lower than the minimum requirement of 25% of the compost sample is to be used as a soil conditioner according to AS4454. Moisture however is not considered a critical factor in terms of application as the soil could be watered after addition of the compost.

In term of chemical constituents, the compost sample consisted of ~ 90% organic matter and ~ 10% ash or inorganic matter. The organic matter content exceeds the minimum requirement stipulated in AS 4454 i.e $\geq$ 25%.

Table 1 : Major Constituents of Compost Produced from Restaurant Food Waste

No.	Parameter	Compost		AS 4454-1997 Requirement[1]
		I[1]	II[2]	
1.	Moisture (%)	-	11.4	25-52
2.	Ash (%)	10.2	9.04	-
3.	Carbon (%)	48.8	43.2	≥25
4.	Hydrogen (%)	7.7	6.8	-
5.	Nitrogen (%)	3.8	3.3	-
6.	Sulphur (%)	<0.009	<0.008	-
7.	Calcium (%)	0.94	0.84	-
8.	Magnesium (%)	0.46	0.41	-
9.	Sodium (%)	0.1	0.09	<1
10.	Potassium (%)	0.62	0.55	-
11.	Phosphorus (%)	0.016	0.014	-

Note: [1] I refers to oven dried sample *[2] II refers to samples as received*

The organic matter determined in terms of matter loss at the ashing temperature of 550 °C could be higher than the actual value as carbonate and structural water are not considered. When organic matter is calculated using the formula:

Organic matter = 1.7 x % C (C is determined by induction furnace)

the value obtained is ~ 83% organic matter content, indicating potential presence of carbonate in the compost sample.

Nevertheless from actual carbon (C)and nitrogen (N) values determined using the induction furnace method, as is the operating principle of the elemental analyser, the C/N ratio for the compost sample is 48.8/3.8 or 12.8. The C/N ratio is ≤ 20, thereby fulfilling the conditional claim that this compost sample can contribute to plant nutrition when applied to the soil. This inference is further deliberated under section c on 'Soluble Constituents'.

In terms of inorganic matter, the major components are salts of calcium, potassium, magnesium and sodium. The analysis has shown sodium is present at < 1% and gypsum need not be added during application of the compost sample.

Based on the major constituents detected in the compost sample, it can be inferred the compost sample is able to meet the requirements for use as mulches and soil conditioners. In the latter case, addition of moisture is necessary to enhance applications.

b) Minor Constituents

The heavy metals were analysed and found to be present at trace concentrations and within limits that are not deemed detrimental to health in general. There were three metals that were detected at higher concentration than the rest, namely iron, zinc and manganese at about 160 mg/kg, 60 mg/kg, and 60 mg/kg respectively. It is unlikely for the metals contamination to have originated from the raw material of the compost which is mainly food waste.

The extract of the compost sample as shown in Table 5 is weakly acidic at around pH 5 - 6. At the operating temperature (said to be 80 °C by the company) and slightly acidic condition, it is possible for the stainless steel or zinc galvanised parts in the composting chamber to corrode. Since corrosion is an operation problem that can be controlled through for example use of more corrosion resistant material or corrosion – resistant coatings, this observation should not poised to be a matter of concern.

Table 2: Minor Constituents of Compost Generated from Restaurant Food Waste

No.	Parameter	Compost		AS 4454-1997 Requirement[1]
		I[1]	II[2]	
1.	Manganese (mg/kg)	60	53	-
2.	Lead (mg/kg)	4.4	3.9	-
3.	Nickel (mg/kg)	7.6	6.7	-
4.	Cadmium (mg/kg)	1.2	1.0	-
5.	Zinc (mg/kg)	59	52	-
6.	Iron (mg/kg)	154	136	-
7.	Chromium (mg/kg)	10	9.1	-
8.	Copper (mg/kg)	5.9	5.2	-
9.	Boron (mg/kg)	12	11	<200
10.	Cobalt (mg/kg)	<0.7	<0.6	-
11.	Molybdenum (mg/kg)	2.7	2.4	-

Note: [1] I refers to oven dried sample *[2] II refers to samples as received*

AS4454 had also specified that compost with concentration of boron < 100 mg/kg can have unrestricted use. The compost sample of this project met the requirement easily.

c) **Soluble Constituents**

AS4454 stated that the mature compost should contain < 3mg/l ammonical nitrogen in the extract, while fresh compost has no fixed requirements. At the same time when Nitrate-N/Ammonical-N ratio is $\geq$ 0.14, the compost falls into the composted/ matured category. The compost sample seemed to have qualified itself as a mature compost (Nitrate-N/Ammonical-N is 0.88) based on these two criteria. However the presence of about 0.16% of TKN indicates that a substantial portion of the organic nitrogen had not degraded to ammonium. This indirectly infers the compost material had not been fully composted.

Table 3: Composition of Soluble Nutrients in Compost Extract

No.	Parameter	Concentration mg/l	AS 4454-1997 Requirement[1]
1.	Total Kjeldahl Nitrogen	1580	
2.	Ammonical - Nitrogen	27.9	<3 mg/kg for mature compost and no requirement for fresh compost
3.	Chloride	3741	N/A
4.	Nitrate	109.3	N/A
5.	Nitrate - Nitrogen	24.6	N/A
6.	Phosphate	12008	N/A

Thus while the total nitrogen was found to be high (about 4%, refer to Table 1), the proportion available as soluble nutrient to plants is low. This observation is further confirmed by the summed value of the ammoniacal-N and nitrate-N at about 53mg/l, which is only about half the value stated in AS4454 for claims on contribution to plant nutrition.

The above observation does imply that the existing composting protocol or conditions may be insufficient to fully compost the restaurant food waste and improved its potential nutritional value.

The soluble phosphorus (assumed about 1/3 of the soluble phosphate detected) far exceeded the limit stated in AS4454 for application of the compost sample on phosphorus sensitive plants. The phosphorus content is a parameter controlled more by the source of raw material rather than the performance of the composting unit. The company may want to consider some variation in the composition of their raw material mix.

d) Physicochemical Properties

The pH value of the compost extract is within the limit set by AS4454. While there is no limit set on the electrical conductivity, the Australian Standard does state an application rate of < $4L/m^2$ for plants that are sensitive to salinity and < $16\ L/m^2$ for plants that are tolerant when the compost material is incorporated into soil to a depth of 5 cm.

Table 4: pH and Electrical Conductivity for Extract of Compost

No.	Parameter	Compost	AS 4454-1997 Requirement
1.	pH	5.6	5.0-7.5
2.	Electrical Conductivity mS/cm	5.31	No limit

e) Phytotoxicity Index

The phytotoxicity index is an indicator to determine whether a compost is sufficiently toxic to inhibit the germination of seeds or growth of roots. The toxicity evaluation of the compost sample was performed using green beans (*Phalseolus radiata*) and the incubation period was over 3 days. These two test parameters differ from those stated in AS4454 mainly due to unavailability of the recommended curl cress seed locally.

Table 5: Plant Toxicity Evaluation for Compost Sample

Sample code	Toxicity Index	AS 4454 Standard for Toxicity index
Compost	49.6	≥ 20 for fresh compost, ≥ 60 for mature compost

The toxicity index of the compost sample was ~ 50%, which fulfills the requirement for fresh compost and ~ 10% less if considered as a matured compost. Nevertheless, there is no necessary to provide instruction for a low application rate since the toxicity index exceeds 20%.

f) Pathogenic Evaluation

Table 6: Pathogenic Evaluation of Compost

Pathogen	Sample result
E.coli	<3 MPN/g
Pseudomonas aeruginosa	0 cfu/g
Salmonella	Absent
Staphylococcus aureus	<10 cfu/g

The compost sample was tested negative to the presence of *Salmonella* and *Pseudomonas Aeruginosa* and less than the detection limits for *E. coli* and *Staphylococcus aureus*. The microbiological results indicate the compost sample is free of pathogens. The high temperature during the composting process (≥ 55 °C) would have destroyed most disease-producing microorganisms.

3. Chemical Properties of Condensate

Sample of water condensing from the exhaust pipe of the composting unit was collected as condensate during the sampling session and tested for its potential impact on the environment when discharged into the public waterways.

Table 7: Compositional Analysis of Condensate Generated from Composting Unit

Parameter	Concentration (mg/l)	Standard B (EQA)
Calcium	2.9	N/A
Magnesium	1.4	N/A
Sodium	3750	N/A
Potassium	2.9	N/A
Manganese	46	1.0
Lead	0.06	0.5
Nickel	0.02	1.0
Cadmium	0.004	0.02
Phosphorus	0.84	N/A
Zinc	28	2.0
Iron	0.89	5.0
Chromium	0.02	1.0
Copper	0.03	1.0
Boron	0.01	4.0
Cobalt	<0.007	N/A
Molybdenum	<0.008	N/A
BOD	158	50
COD	1035	100
Ammonical-Nitrogen	354	N/A
Total Kjedahl Nitrogen	30	N/A
pH	6.43	5.5-9.0
Electrical Conductivity	0.33	N/A

Table 7 shown the condensate can pose a risk to environmental pollution especially in terms of its BOD, COD, zinc and manganese concentrations, all of which have exceeded the limits set by the Third Schedule, Environmental Quality (Sewage and Industrial Effluents) regulations, 1979, Parameter Limits of Effluent of Standard B.

The higher nitrogen contents in term of ammonical and organic nitrogen also show that the composting process has not advanced to a sufficiently advanced stage to have maximised the nutritional value of the food waste source material.

4. Gaseous Measurements

Table 8: Gas Measurement of composting unit on 10th October 2001

Time	Carbon dioxide (%)	Oxygen (%)	Stack Temperature (°C)
Reading 1	0	20.9	36
Reading 2	0.6	19.8	40
Reading 3	0.6	19.7	48
Reading 4	0.9	19.2	89

The temperature within the composting has seemed to fluctuate from 36-89 °C. However the variation is caused more by the sampling technique and time permitted for the probe to be in equilibrium with its surrounding. The higher temperature detected at about 90 °C occurred when the side door was closed as much as possible and the probe left in the compost mass for more than 15 minutes. The oxygen and carbon dioxide readings were consistent throughout the measurement period.

Oxygen is consumed during the composting process by the active microorganisms while carbon dioxide is produced. Oxygen and carbon dioxide measurements were taken by inserting the probe of a gas analyser into the composting mass through a side door opening.

The results of the gas measurement seem to indicate very little microbial activity within the composting unit. The oxygen content had maintained almost to the level characteristic of normal ambient atmospheric condition, while carbon dioxide was about two times higher. Although the composting unit is equipped with a suction system that continually permits a fresh flow of air through the composting mass, there are at least three observations that seem to indicate insufficient microbial activity.

The chemical composition, in particular the high ammonical and organic nitrogen content of the compost and condensate samples are likely related to inadequate degradations of the food waste, which is high in meat content rather than plant based materials.

The temperature to which the composting mass is subjected to at ~ 80 °C could be too high even for the thermophilic organisms. The optimum temperature range for composting is generally about 50 –70 °C.

5. General Comments

Based on results obtained from laboratory investigation, the following conclusions are inferred:

- **Compost**

The compost generated from the composting unit does fulfill the requirements of Australian Standard 4454 – Soil Conditioners, Composts and Mulches if certain conditional statements are mentioned, for example, the maximum rate of application for electrical conductivity in the 4-8 dS/m range. The high total kjeldhal nitrogen value is indicative that degradation has not reached its optimum level. This has created a situation where seemingly the compost has high nutritional value in terms of nitrogen content, but in reality, contains relatively low amount of the form of nitrogen (i.e. nitrate-nitrogen) that is easily taken up by plant. Since the other parameters are favorable, it is worthwhile for S.E.N. Tech. Sdn. Bhd. to study the current composting process.

- **Condensate**

It is critical to control the rate of discharge of the condensate to the public waterway as it is found to contain high concentration of organic pollutants. However due to the small discharge volume that is < 1 m^3/day, the pollutant load of the condensate in term of BOD is about 0.2 kg/day. This is less than the permissible load of 6 kg/day whereby the condensate will need to be treated prior discharge according to First Schedule, Environmental Quality (Sewage & Industrial Effluents) Regulations 1979. In term of heavy metal, steps must be taken to reduce the corrosion rate of the composting unit to ensure the concentration of zinc and manganese will also comply with the regulations.

- **Composting Unit**

The composting unit that was evaluated in this project does not follow the typical composting principle of operation. With the continual forced injection and removal of air into the system, the composting mass is always in aerobic conditions with an oxygen content that is similar to the normal atmospheric condition. This in principle should give rise to a high composting rate which did not seem to occur with the detection of a high concentration of organic nitrogen.

The temperature set for the composting unit at about 80 °C is high when compared to the optimum temperature of about 65 °C for good microbial activity and destruction of pathogens. It was not possible to determine the temperature profile of the entire composting mass. Nevertheless some consideration should be given to the need for such a high temperature.

APPENDICES

Appendix A

SAMPLING REPORT FOR COMPOST GENERATED FROM RESTAURANT FOOD WASTE

Name of Company : S.E.N. Tech Sdn. Bhd..
No.8, Jalan Margosa SD 10/4B,
Bandar Sri Damansara, 52200 Kuala Lumpur.

Sampling site : Hakka Restaurant
34, Jalan Kasawari 8, Taman Eng Ann,
41150 Klang, Selangor.

1.0 Objective of Sampling Effort

To ensure the samples of compost and condensate collected will be representative of variability of compost/ condensate generated from a food waste composting unit.

2.0 Description of Sampling Site and Samples

The composting unit was located at the back of the restaurant occupying a site of about 1500 mm x 900 mm.

Compost sample collected from composting unit was a fine powdery and dry yellowish brown material.

Condensate sample from the condenser of the composting unit was a clear, light brown liquid.

3.0 Sampling Strategy

The sampling plan was developed to obtain a representative sample of the compost produced by the food waste composting unit that is operated in tandem with the restaurant operation.

The compost sample was then tested to assess their compliance with Australian Standard 4454-Soil Conditioners, Compostes and Mulches. Additional scope of assessment includes heavy metal contamination, pathogenic evaluation and plant toxicity characterisation.

A representative sample of condensate from the condenser was collected and analysed for identified pollutants.

Gaseous measurement for oxygen and carbon dioxide within the composting unit was carried out to determine the capability of the system to maintain an aerobic condition for good composting.

4.0 Sampling Procedure

4.1 Labeling Exercise

The compost and condensate samples collected were labelled as "compost" and "condensate", respectively and dated accordingly.

4.2 Choice of Sampling Points

The compost sample that was collected during the sampling session was obtained after the grinding and sieving stages. According to the company, the sample would be typical of the form that will be supplied to their clients.

The condensate sample was collected from the singular outlet located at the bottom of the condenser.

Oxygen and carbon dioxide measurements were taken within the compost pile through a detachable side opening where the probe of the gas analyser could be easily placed.

4.3 Procedure for Acquiring Samples

It was not practical to obtain a compost sample over a stipulated time period. Hence, only a grab sample was collected on the sampling session day.

The condensate sample was collected using a plastic bag placed almost flat on the ground. The collected condensate was then transferred to the sampling containers.

Gaseous measurement was carried out using Telegan gas analyser that produced continuos readings over the sampling duration.

4.4 Miscellaneous

Sampling activities were carried out by two SIRIM personnel from 2.30 p.m. to 4.30 p.m on 22 October 2001.

The weather was fine on the day of sampling, ambient temperature recorded as 31 °C.

Photographs illustrating the various activities during the sampling session were taken for reporting purposes and attached in Appendix B.

A SELECTION OF PHOTOGRAPHS ON SAMPLING SESSION

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APPENDIX C

Pusat Teknologi Alam Sekitar dan Tenaga
Environmental and Energy Technology Centre

Bangunan 15, SIRIM Berhad, Shah Alam, Selangor Darul Ehsan
Tel: 60-3-55446550, 55446598 Fax: 60-3-55446590

SIRIM

RESULTS SUMMARY

- Company Name : S.E.N. Tech Sdn. Bhd.
- Address : No.8, Jalan Margosa SD 10/4B, Bandar Sri Damansara 52200 Kuala Lumpur. (Attn : Mr. Jeffery Chong)

Your Ref No.	-
SIRIM Ref. No.	ETC237/16/234
Job No.	J194/01
Report No.	R195/01
Date of Issue	30/11/01
No. of pages	4

Request : Analysis of Compost Generated from Food Waste

SAMPLE DESCRIPTION

A sampling session was carried out on 10th October 2001 by two SIRIM personnel. Two samples were obtained from the sampling session and labelled as :-
(a) Compost
(b) Condensate

TEST METHOD

Please refer to page 2.

RESULTS

Please refer to page 3 and 4.

INFERENCE

Nil

Name	**Tan Yong Nee (A.M.I.C)**
Designation:	**Researcher**
Fax No:	**03-55446590**
Tel. No:	**03-55446591**

J194/01

TEST METHOD

*(1) **Extraction of Compost According to Appendix A AS4454-1997.**

- Extraction fluid : distilled water
- Rotation speed of agitation apparatus :10 rpm.
- Extraction duration : 90 minutes
- Pore size of filter media : 0.65um

The extract was used for:

+1.1 Determination of total kjeldahl nitrogen according to APHA 4500-N_{org} B

+1.2 Determination of ammonical-nitrogen according to Hach 8038

1.3 Determination of pH according to APHA 4500^{+}

*1.4 Determination of electrical conductivity using HORIBA Conductivity Meter DS- 15.

*1.5 Determination of toxicity to plants.

A modified method for determination of plant toxicity according to Appendix E AS4454-1997 was carried out as follows :-

- Place a single sheet of filter paper on the dish
- Eight green seeds were distributed in each dish.
- Place 2.5ml of extract onto filter paper.
- Incubate for 67 hrs at 26 $\pm$ 2 ^{o}C.
- Measure the radicle length of each dish.

+1.6 Pathogenic evaluation according to FDA 4.0F, APHA, RT Rambach, FDA 12.0D.

(2) **Compositional Analysis of Compost**

2.1 Determination of moisture content according to BS EN 12880 :2000

2.2 Determination of ash content according to BS EN 12879 2000

2.3 Determination of carbon, hydrogen, nitrogen and sulphur using E.A 1108 CHNS-O analyser.

*2.4 Digestion of compost according to Appendix C AS4454-1997.

*2.5 Elemental analysis of compost digestate according to APHA 3120B.

2.6 Determination of anions for disgestate according to APHA 4110B.

(3) **Analysis of Condensate**

3.1 Determination of pH according to APHA 4500^{+}

*3.2 Determination of electical conductivity using HORIBA Conductivity Meter DS- 15

+3.3 Determination of total kjeldahl nitrogen according to APHA 4500-N_{org} B

+3.4 Determination of ammonical-nitrogen according to Hach 8038.

3.5 Determination of biochemical oxygen demand according to APHA 5210B

3.6 Determination of chemical oxygen demand according to APHA 5220D.

*3.7 Digestion of condensate in nitric acid according to APHA 3030E.

*3.8 Heavy metals analysis of digested condensate according to APHA 3120B.

Note : + subcontracted and accredited

** non-accredited method.*

RESULT

Table 1 : Physico-Chemical Properties of Compost Extract and Condensate

Sample Code	pH	Electrical Conductivity/ mS/cm
Extract (Compost)	5.60	5.31
Condensate	6.43	0.33

Table 2 : Compositional Analysis of Compost

Parameter	Compost	
	[1]Compositional (mg/kg) (oven dried)	[1]Compositional (mg/kg) (sample as received)
Moisture	NA	11.4%
Ash	10.2%	NA
Calcium	0.94%	0.84%
Magnesium	0.46%	0.41%
Sodium	0.1%	0.09%
Potassium	0.62%	0.55%
Carbon	48.8%	43.2%
Hydrogen	7.7%	6.8%
Nitrogen	3.8%	3.3%
Sulphur	<0.009%	<0.008%
Lead	4.4	3.9
Nickel	7.6	6.7
Cadmium	1.2	1.0
Zinc	59	52
Iron	154	136
Chromium	10	9.1
Copper	5.9	5.2
Boron	12	11
Cobalt	<0.7	<0.6
Molybdenum	2.7	2.4
Manganese	60	53
Phosphorus	156	138

Note : [1]All units in mg/kg for compositional unless stated otherwise.
[2]NA-Not Applicable

Table 3 : Analysis of Compost Extract

Parameter	Concentration (mg/l)
Total Kjeldahl Nitrogen	1580
Ammonical-Nitrogen	354
Chloride	3741
Nitrate	109.3
Phosphate	12008

Table 4 : Analysis of Condensate

Parameter	Concentration (mg/l)
Calcium	2.9
Magnesium	1.4
Sodium	3750
Potassium	2.9
Lead	0.06
Nickel	0.02
Cadmium	0.004
Zinc	28
Iron	0.89
Chromium	0.02
Copper	0,03
Boron	0.01
Cobalt	<0.007
Molybdenum	<0.008
Manganese	46
Phosphorus	0.84
Total Kjeldahl Nitrogen	30
Ammonical-Nitrogen	27.9
BOD	158
COD	1035

Table 5 : Result of Compost Extract on Toxicity to Plants

Sample code	Mean radicle length/mm	Phytotoxicity value
Control	3.15	-
Compost	1.56	49.6

Table 6 : Result of Pathogenic Evaluation of Compost

Pathogen	Sample results
E. coli	<3 MPN/g
Pseudomonas aeruginosa	0 cfu/g
Salmonella	Absent
Staphylococcus aureus	<10 cfu/g