Selection of Indigenous Microorganisms in Enhancing Imo-Compost Production

A. Norida Hanim[1], M. Nik M. Majid[2], O. H. Ahmed[1*], K. Susilawati[1] and A. Khairulmazmi[1]

[1]*Department of Crop Science, Faculty of Agriculture and Food Science, Universiti Putra Malaysia, Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia.*
[2]*Department of Forest Management, Faculty of Forest, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.*

Corresponding author's e-mail:

Abstract

Microorganism is one of the important factors that controlled composting processes and commonly effective microorganism (EM) is used to promote compost quality. However low income farmers generally has difficulties in using it due to its availability and cost. Thus identification of local microbial sources which are cheap and sensible is needed for the production of high quality IMO-compost. The objective of this study is to identify the effect of different indigenous microorganisms (IMO) sources on compost quality. Three different IMO sources were selected which were steamed white rice (SWR), aerated fish pond water (AFPW) and kitchen waste (KW). IMO from those sources were added to compost pile and selected parameters such as humic acid (HA) content, temperature changes, nutrient content, C/N and C/P ratio, pH, rate of decomposition and cation exchange capacity (CEC) were used as the indicators for compost quality. All IMO compost attained an ambient temperature at 34 days of composting indicating the stable nature of the composts. It shown the highest HA content in AFPW-IMO compost (T4) and lowest in KW-IMO compost with (11.6%) and (8.4%) respectively. The total N, P, K, C/N and C/P ratio, pH, TOC, OM and CEC shown the high positive relationship with HA content indicated the high quality of AFPW-IMO compost from corn stalk (CS) residue. It can be concluded that, AFPW is the best sources for IMO in our local environment.

Keywords: IMO-compost, Humic acid, Steamed white rice (SWR), Aerated fish pond water (AFPW) and Kitchen waste (KW).

Introduction

Compost is the product of aerobic process during which microorganisms play an important role. Essentially, the microorganisms decompose the organic matter into a stable amendment for improving soil quality and fertility. During composting, the microorganisms use the organic matter as a food source. The process produces heat, CO_2, H_2O vapor and humus as a result of the growth and activities of microorganisms. The success of the composting process, however, relies on the ability of the microbial community to sustain its basic needs for moisture, oxygen, temperature control and nutrient availability. Agronomists often used effective microorganisms (EM) and beneficial microorganisms (BM) in agriculture, aquaculture, marineculture and industries. Most of EM and BM are applied mainly in three forms from selected culture, single, multiple and compound strains which are costly compared the IMO from natural sources [1]. In this study, IMO were cultured from three different natural sources; i) steamed white rice (SWR), ii) aerated fish pond water (AFPW), and iii) kitchen waste (KW) to an enhanced composting process. Steamed white rice (SWR) known as carbohydrate source was used in trapping beneficial IMO under bamboo plant litter. Bamboo attracts powerful IMO as the roots of the bamboo exude sugary substances that attract IMO [2,3,4,5]. Bacteria are naturally present in aerated fish pond water (AFPW) and sediment, being regarded as integral to the biological structure, acting upon the metabolism of the aquatic ecosystem and bearing a basic role to water quality also in contribution to mineralization, utilization as probiotic and employment of certain in fish breeding systems in pond [6,7]. Food and organic wastes mostly consists of uneaten food and food preparation waste especially from residences, restaurants and cafeteria known as kitchen waste (KW). Its characterized by high organic content containing soluble sugars, starch, lipids, proteins, cellulose, and other compounds that are readily biodegradable [8,9], and generally contain few compounds that inhibit bacteria [10]. Thus, the objective of this study is to identify the effect of different indigenous microorganisms (IMO) sources on compost quality.

Materials and Methods

Indigenous microbes were collected from three local sources. i) undisturbed area under bamboo trees using steamed white rice (SWR), ii) aerated fish pond water (AFPW), UPM fish pond, and iii) kitchen wastes (KW) from food stores at Universiti Putra Malaysia Bintulu Sarawak Campus. Water samples were collected in sterilized 5 L bottle and taken to the laboratory in an isothermal material box containing ice cubes [6]. The time between collection and seeding in culture medium was at most 5 hours. KW was collected from Sri Rajang College Cafeteria (2) with a ratio of (rice, meat and a vegetable, 3:1:1). Distilled water was added gradually equal to the weight of the kitchen waste mass and ground using food blender [11]. The AFPW and KW were left to ferment at 30 ± 2°C for 5 days until all the solid form changed to slurry form. Bamboo trees attract powerful beneficial microorganisms as the roots of the bamboo exude sugary substances that attract beneficial microorganisms [12]. Small wooden box (30 x 15 x 10 cm) was filled with 5 cm of steamed white rice (SWR) and covered with paper towel. Rubber bands were used around the top of the box to secure the paper towel in place. The top of the box was covered with wire screen to prevent animals from tampering with the rice also covered with a sheet of plastic to protect the box from rain before placed it under bamboo trees without direct sunlight. The box was partially buried 5 cm deep in the soil and covered with fallen leaves. The plastic sheet was anchored on all sides with small rocks to prevent it from being dislodged by wind. The box was left for 5 days. After this period, the moist rice was covered with white mold (mycelium) and during this phase; Indigenous Microorganisms (IMO), IMO(I) was obtained [13]. The desired microbes from different sources (SWR, AFPW and KW) were cultured to increase their population. Granulated brown sugar and molded rice were mixed in a ratio of 1:1. About 1.3 kg of molded rice and granulated brown sugar were weighed and hand kneaded until the material had the consistency of gooey molasses and then transferred to a clean glass bottle filled two-third full and covered with paper towel secured in place with rubber bands. The bottle was stored at 30 ± 2°C for 5 days to allow the mixture to ferment [13]. Similar procedure was used to process AFPW and KW. After this period, second phase of indigenous microorganisms called IMO(II) was produced. A 2.5 g of fermented SWR, AFPW and KW were mixed together with 1 L fermented rice waste water for each followed by addition of 2.5 kg of ground corn, until the mixture was semi moist (roughly 65 to 70% moisture). A mound of the mixture was placed in polystyrene box at 30 ± 2°C to protect it from the sunlight and allow the microbes to propagate for 5 days and IMO(III) were produced in this phase. A 3.5 kg of IMO(III) and air dried soil were mix gradually and allowed to ferment for 15 days at 30 ± 2°C and IMO(IV) was produced. Two agriculture residues; corn stalk (CS) and paddy husk (PH) were collected from university farm, Universiti Putra Malaysia Bintulu Campus Sarawak used for composting inside a white polystyrene box with a size of 30 x 15 x 25 cm. The composting process and IMO were allowed to propagate until the temperature of the compost equalled to ambient temperature after 34 days. The mature samples were collected for analysis and HA extraction. The experiment had the following treatments:

(T1) IMO(IV)SWR (30%) + PH (40%) + CD (30%),
(T2) IMO(IV)SWR (30%) + CS (40%) + CD (30%),
(T3) IMO(IV)AFPW (30%) + PH (40%) + CD (30%),
(T4) IMO(IV)AFPW (30%) + CS (40%) + CD (30%),
(T5) IMO(IV)KW (30%) + PH (40%) + CD (30%), and
(T6) IMO(IV)KW (30%) + CS (40%) + CD (30%).
*CD = Chicken Dung

Kjedhal method was used to determine total N [14]. Decomposition was calculated after ignition of the dry sample at 550°C for 8 hr [15]. Compost total P was extracted using the single dry ashing method followed by blue method [16]. Compost CEC was determined by the leaching method followed by steam distillation [14]. The pH of the compost was determined in 1:4 compost: distilled water suspension and KCl using a glass electrode [15]. The HAs extraction was carried out by method of [17]. All the experiments were conducted in a completely randomized design (CRD) with three replications. The data were subjected to analysis of variance (ANOVA) and tested for significance using Tukey's Test (SAS version 9.2) by PC-SAS software (SAS Institute, Cary, NC, USA, 2008) [18].

e-ISBN 978-967-5366-93-2

Results and Discussion

Figure 1 shows the average temperature curve of composted PH and CS with involved three IMO treatments from SWR, AFPW and KW. During aerobic composting, the average temperature curve within all the treatment showed four phases (Fig. 1). *Initial mesophilic phase*. Psychrophilic and mesophilic microorganisms in piles tend to increase during at 2nd day of composting cycle (Fig. 1). During this phase, temperature increased to 10 to 42˚C as a consequence of biodegradation of organic compounds. *Thermophilic phase*. Temperatures of T4 (AFPW IMO compost) and T6 (KW IMO compost) rose to 53.4˚C and 55.6˚C respectively compared to other treatment with range between 44 to 50˚C after 3 to 5 days of composting. *Middle mesophilic phase*. Only temperature of T1 and T2 (SWR IMO compost) and T6 (KW IMO compost) decreased from 65 to 50˚C at day 8, while the rest decreased slowly at day 9. *Cooling phase*. The temperature began to decrease after day 10. This decrease resulted in the beginning of depletion of organic matter and average temperatures inside the different piles marked a real fall with values of approximately 25.8˚C (Fig. 1).

The pH of IMO-composts was neutral to alkaline due to degradation of acid type compounds like carboxylic and phenolic groups or mineralization of compounds such as protein, amino acids and peptides to ammonia. The higher pH value in IMO-compost is useful in increasing soil pH with application of IMO-compost especially in acid sulphate soil generally widespread in Sarawak regions. Acid sulphate is soil low in basic cations and also low in soil cation exchange capacity and application of IMO-compost could be solve a these problem. Linear correlation with (R^2 = 0.536 and 0.791) value between pH (w) and pH (KCl) and HA yield was also found to be significant (Fig. 2). T4 (AFPW IMO compost (KW IMO compost) was neutral in high pH level compared the other treatment. The C/N, C/P ratio, OM had correlation with mineralization and humification resulting the ash content and HA yield (Table 1). Linear correlation with weak positive correlation (R^2 = 0.270 and 0.776) value between C/N and C/P ratio and HA yield while highly the coefficient of correlation (R^2) value (0.135) for TOC and OM showed that both were highly correlated with HA yield (Fig. 2). It revealed that when the IMO-compost is having high OM it increased high organic TOC in HA. The high ash content resulted in high content of minerals which also reflect the increase in CEC. CEC suggests high amount of minerals in the IMO-compost which are very essential for plant growth and development. A weak positive correlation (R^2 = 0.499) was found between total N content in IMO-compost with HA yield, while strong positive correlation on total P and K with R^2 = 0.955 and 0.922 respectively. The relationship between the total N content and the degree of humification of HA has been discussed by Tsutsuki and Kuwatsuka, shown that N content increases in the early stage of humification and then decreases with increasing degree of humification [19].

e-ISBN 978-967-5366-93-2

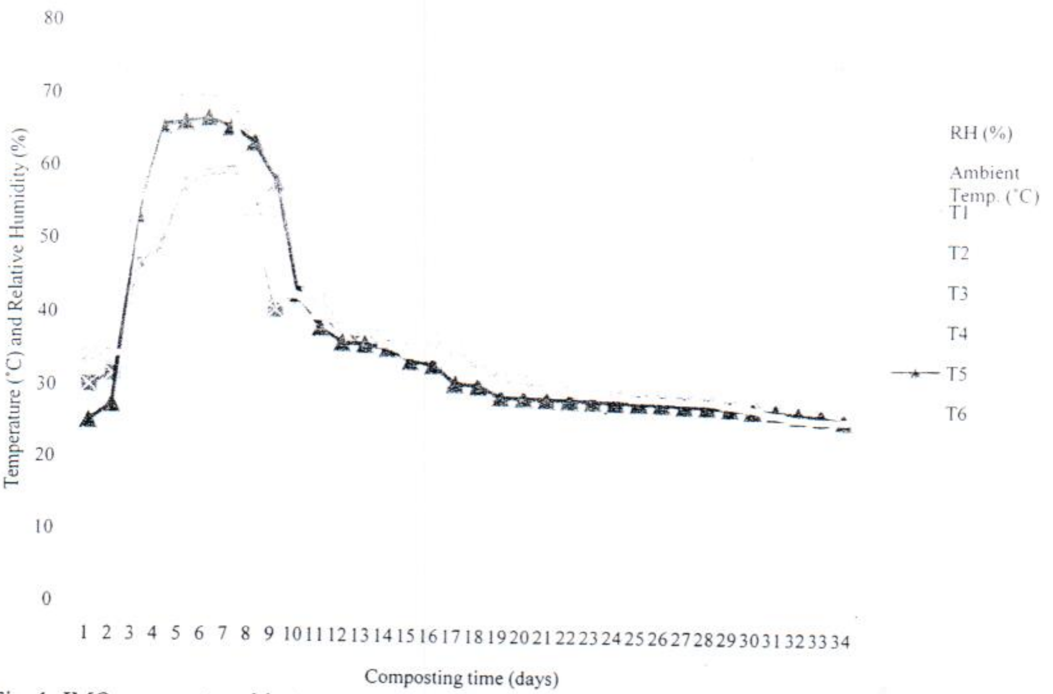
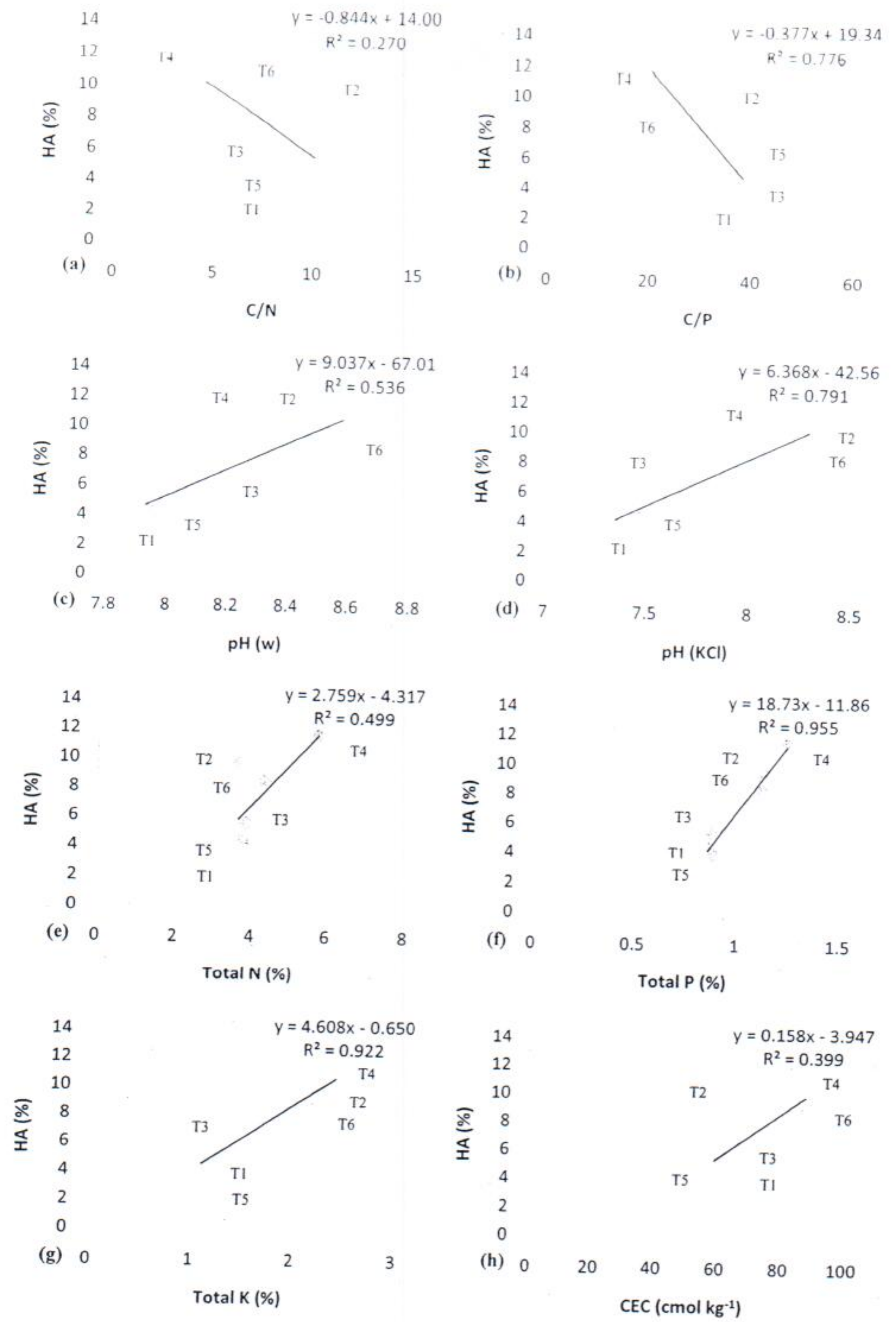


Fig. 1: IMO-compost, ambient temperatures and relative humidity over 34 days of composting.

Table 1. Physico-chemical properties of different IMO-Composts.

Characteristics	T1	T2	T3	T4	T5	T6
pH_{water}	7.93^{c}	8.40^{ab}	8.16^{bc}	8.27^{abc}	7.96^{c}	8.58^{a}
pH_{KCl}	7.35^{b}	8.29^{a}	7.47^{b}	8.10^{a}	7.47^{b}	8.25^{a}
N (%)	3.80^{a}	3.66^{a}	3.85^{a}	5.75^{a}	3.75^{a}	4.33^{a}
P (%)	0.89^{bc}	1.13^{ab}	0.88^{bc}	1.24^{a}	0.86^{c}	1.12^{abc}
K (%)	1.12^{b}	2.27^{a}	1.11^{b}	2.43^{a}	1.14^{b}	2.21^{a}
C/N ratio	8.37^{a}	10.06^{a}	8.93^{a}	4.44^{a}	8.63^{a}	7.60^{a}
C/P ratio	36.11^{a}	32.38^{a}	38.37^{a}	20.04^{a}	38.38^{a}	27.09^{a}
CEC (cmol kg^{-1})	66.00^{b}	64.00^{b}	62.67^{b}	83.33^{a}	59.33^{b}	89.67^{a}
TOC (%)	31.71^{a}	36.73^{a}	33.25^{a}	25.13^{a}	32.09^{a}	30.16^{a}
Ash (%)	45.33^{a}	36.67^{a}	42.67^{a}	56.67^{a}	44.67^{a}	48.00^{a}
OM (%)	54.67^{a}	63.33^{a}	57.33^{a}	43.33^{a}	55.33^{a}	52.00^{a}
HA (%)	3.97^{c}	9.70^{ab}	5.47^{c}	11.60^{a}	4.33^{c}	8.40^{b}

Different letters within a column indicate significant difference between means using Tukey's Test at $p = 0.05$.



e-ISBN 978-967-5366-93-2

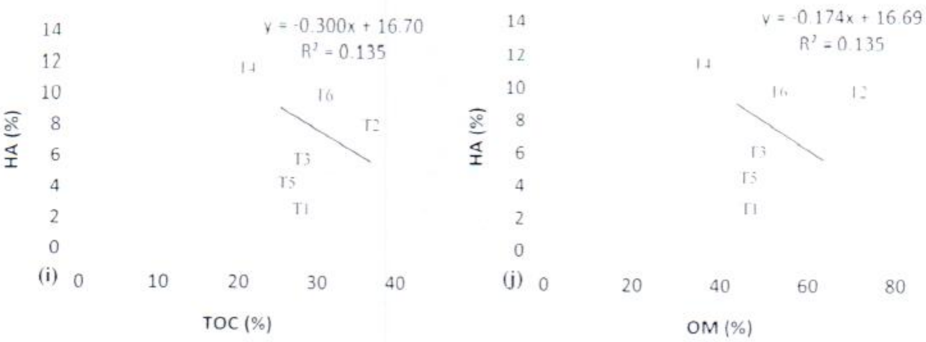


Fig. 2: Relationship of humic acid (HA) yield with; (a) C/N, (b) C/P, (c) pH in water, (d) pH in KCL, (e) Total N, (f) Total P, (g) Total K, (h) CEC, (i) TOC, and (j) OM determined in IMO-compost; (T1) SWR-PH, (T2) SWR-CS, (T3) AFPW-PH, (4) AFPW-CS, (T5) KW-PH, and (T6) KW-CS.

Acknowledgements

This research was partially supported by Fundamental Research Grant Scheme (FRGS) (No. : 91784-2) from the Ministry of Higher Education, Malaysia.

References

[1] Q. Zhou, K. Li, X. Jun and L. Bo. Role and functions of beneficial microorganisms in sustainable aquaculture. Bioresource Technology Vol. 100 (2009), p. 3780-3786.

[2] J.L. Kirk, L.A. Beaudette, M. Hart, P. Moutoglis, J.N. Klironomos, H. Lee and J.T. Trevors. Methods of studying soil microbial diversity. Journal of Microbiological Methods Vol. 58 (2004), p. 169-188.

[3] M. Mazzola. Influence of plant genotype on development of intrections with non-symbiotic plant beneficial soil microorganisms. Research Signpost: Research Developments in Agricultural and Food Chemistry Vol. 37 (2004), p. 103-122.

[4] C.H. Kyu. Natural farming. Janong Natural Farming Institute, Chungbuk, Rebublic of Korea (2003).

[5] N. Szmanski and R.A. Patterson. Effective microorganisms (EM) and waste management systems in future directions for on-site systems: Best management practice. Proceedings of the On-site '03 Conference, University of New England, Lanfax Laboratories Armidale (2003), p. 347-354.

[6] C.F. Macedo, L.A. Amaral and L.H. Sipaúba-Tavares. Microbiology quality in continous water flow fish ponds. Medical Veterinária Vol. 32 (2011), p. 701-708. DOI: 105433/1679-0359.2011v32n2p701.

[7] L.H. Sipaúba-Tavares and F.M. de S. Braga. The feeding activity of *Colossoma macropomum larvae* (tambaqui) in fish ponds with water hyacinth (*Eichhornia crassipes*) fertilizer. Brazil Journal of Biology Vol. 67 (2007), p. 459-466.

[8] S.H. Halimatun, A.R. Nor Aini, O. Farah Nadia, L.Y. Phang, A. Suraini and H. Mohd Ali. A comparative study of organic acids production from kitchen wastes and simulated kitchen waste. Australian Journal of Basic and Applied Sciences Vol. 4 (2010), p. 639-645.

[9] P.K.S. Village. Characterization of Manucipal Solid Waste in the United State. 1997 Uptake. US Environmental Protection Sgency Municipal and Industrial Solid Waste Division (1998).

[10] Q.H. Wang, Z. Xu and L.H. Meng. Influence of temperature on production of lactic acid from kitchen waste garbage. Harbin Institute Technology Vol. 10 (2003), p. 195-199.

[11] X.M. Wang, Q.H. Wang, N.Q. Ren and X.Q. Wang. Lactic acid production from kitchen waste with a newly characterized strain of *Lactobacillus plantarum*. Chemical and Biochemical Engineering Quarterly Vol. 19 (2005), p. 383-389.

[12] A. Arunachalam and K. Arunachalam. Evaluation of bamboos in eco-restoration of 'jhum' fallows in Arunachal Pradesh: ground vegetation, soil and microbial biomass. Forest Ecology and Management Vol. 159 (2002), p. 231-239.

[13] H. Park and M.W. DuPonte. *How to cultivate indigenous microorganisms*. Biotechnology. BIO-9. Collage of Tropical Agriculture and Human Resources, University of Hawaii, Mānoa. August 2008.
[14] J.M. Bremner. Total Nitrogen. In, Method of soil analysis, Part 2, Black CA, Evants, D.D., Ensminger, L.E., White, J.L., Clark, F.E., Dinauer, R.C., (Eds.), American Society of Agronomy, Madison, Wisconcin, (1965) p. 1149-1178.
[15] K.H. Tan. Soil sampling, preparation, and analysis (2nd Ed.). Boca Raton, Florida, USA (2005).
[16] J. Murphy and J.P. Riley. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta Vol. 27 (1962), p. 31–36.
[17] F.J. Stevenson. Humus chemistry: Genesis, composition, reactions. (2nd Ed.) John Wiley & Sons, New York (1994). p. 36.
[18] SAS, SAS/STAT Software. SAS Institute, Cary, NC (2008).
[19] K. Tsutsuki and S. Kuwatsuka. Nitrogen distribution in humic acids. Soil Science and Plant Nutrition Vol. 24 (1978), p. 561-570.