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Isolation and Identification of Bacteria Associated with the Compost Generated from Cocoa Pod Husk and Cow Dung

***[1]Adeleye, A.O., [2]Onokebhagbe, V. O., [2]Nkereuwem, M. E., [3]Omeke, J.O. and [4]Yerima, M. B.**

[1]Department of Environmental Sciences, Federal University Dutse, Dutse, Jigawa State.
[2]Department of Soil Science, Federal University Dutse, Dutse, Jigawa State.
[3]Department of Crop and Forestry, National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria, Kaduna State.
[4]Department of Microbiology and Biotechnology, Federal University Dutse, Dutse, Jigawa State.

**Corresponding Author: (adeniyi.adeleye@fud.edu.ng ; 08162784457)*

Abstract
Generation of compost from organic materials has been in practice for numerous decades. This study was conducted to isolate and identify bacteria responsible for the composting of Cocoa pod husks (CPH) and Cow dung (CD).Ten kilogram of fresh Cocoa pod husks and 10.0 kg of Cow dung were composted for twenty days with a view to generating compost from the mixture. One gram of the compost was weighed and suspended into three test tubes containing 9.0 ml sterile distilled water. The mixture was vigorously shaken to give room for the formation of supernatant. Subsequently, 1.0 ml of the supernatant was introduced into test tubes containing Mineral Salt Medium (MSM).The mixture in the test tubes was then shaken vigorously and allowed to settle. The test tubes were subsequently incubated at 37.0 ^{0}C for four days and observed for bacterial growth indicated by broth medium turbidity. Bacterial growth observed after incubation was sub-cultured into three test tubes containing Trypticase Soy broth (TSB) and incubated at 37.0 ^{0}C for 48 hours. Further subculturing was carried out using three Trypticase Soy Agar (TSA) plates at 37.0 ^{0}C for 48 hours and colonies (C_1, C_2, C_3, C_4, C_5, C_6, C_7 and C_8) that developed were observed and recorded. Bacterial colonies were subsequently picked and transferred to other glass slides to form smears. Gram staining procedures and biochemical tests were subsequently conducted. The results of the biochemical tests conducted on C_1, C_2, C_3, C_4, C_5, C_6, C_7 and C_8 indicated *Alcaligenes feacalis*, *Streptococcus* sp, *Serratiamarcescen*s, *Pseudomonas* sp, *Flavobacterium* sp, *Escherichia coli*, *Bacillus stearothermophilus* and *Bacillus subtilis* as the isolated bacteria. However, molecular identification of the bacterial isolates is recommended with a view to further confirming their identity.

Keywords: Composting, Cocoa pod husk, Cow dung, Bacterial isolates, Biochemical tests

1. Introduction
Apart from microbial break down of organic materials principally for microbial metabolic activities, it has been reported that microorganisms that are indigenous in a typical compost heap help in the restoration of the natural cycling of nutrients in the soil leading to the production of soil organic matter_(Adegunloye and Olorunnusi, 2016). Compost generated

from the composting of organic materials has been documented to be rich in nutrients that can adequately enhance crop growth (Jin-Hyung *et al.*, 1996), very cheap as it is principally made of waste materials, renewable and can conveniently substitute the use of inorganic fertilizers that are somehow out of reach for local farmers (TNAU, 2009).

According to Oladokun (1995), *Theobroma cacao* is known as an important tropical rain forest species grown for its oil rich seeds that produce cocoa and cocoa butter. The author reported further that a typical cocoa pod houses about 42% beans, 2% mucilage and 56% pod husk. Raymond and Ray (1992), gave a breakdown of beef cattle waste composition as 2 .8 % N, 1.0 – 2.0 % P, 1.0 – 3.0 % K, 1.5 % Mg, 1.0 – 3.0 % Na and total soluble salts 6.0 – 15.0 %. The application of cow dung in the correct proportion has the tendency of improving soil pH, organic matter, available phosphate and exchangeable cations of the soil. Its application to soil also increases all agronomic variables of crops (Jin-Hyung *et al.*, 1996).

Composting is the biological transformation of organic wastes, under the influence of controlled conditions, into a hygienic, humus-rich, comparatively biostable product that improves land and ultimately improves plant growth (Mathur, 1991). It is an arduous process involving degradation of organic waste aerobically through the metabolic activities of microorganisms; bacteria, fungi and actinomycetes (Hassen *et al.*, 2001; Ryckeboer *et al.*, 2003; Anastasi *et al*., 2005; Bhatia *et al.*, 2013; Pan and Sen, 2013). However, bacteria are responsible for most of the decomposition and heat generation that occur in a typical compost pile (Trautmann and Olynciw, 1996) and this is due to the ability of bacteria to employ a wide range of enzymes to break down organic materials chemically (Sonia *et al*., 2002; Kutu *et al.*, 2019). Efficient composting requires optimum conditions that ensure optimum growth of the microorganisms aiding the process (Adegunloye *et al*., 2007).

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Composting has ability to combine the effect of pathogen reduction with stabilization and conversion of organic wastes into product that can be simply touched and applied to improve soil fertility (Martin and Gershuny, 1992; Zhu, 2006). Composting is one of the needed sanitization processes to lessen animal wastes' microbial load. The efficiency of composting in ensuring pathogens' inactivation greatly depends on allocated time and generated temperature. Ineffective composting process harbours tons of pathogenic bacteria which may be invariably passed on to the end users (Adegoke *et al*., 2016). This study was conducted with the aim to isolate and identify the bacteria involved in the composting of cocoa pod husks and cow dung.

2. Materials and Methods

2.1. *Collection of Fresh Cocoa Pod Husks and Cow Dung*

Thirty kilogram (30.0 kg) of fresh cocoa pod husks (CPH) was collected from cocoa pod husk heaps inside one of the cocoa plantations located at Irasa community, Ado Ekiti, Ekiti State. The cocoa plantation where the CPH was collected shares boundary with Ekiti State University farms and main campus. Similarly, 30.0 kg of cow dung (CD) was collected from the Liarage in Dutse Abbatoir, Jigawa State.

2.2. *Preparation of Cocoa Pod Husk and Cow Dung*

All the unwanted components; twigs, dried cocoa seeds and leaves in the CPH were taken off so as to give room for effective composting system. The collected CD was equally sorted by ensuring that all unwanted materials; stones and twigs were taken off completely.

2.3. *Composting System*

Composting of 10.0 kg of fresh Cocoa pod husks and 10.0 kg of Cow dung was done with a view to generating compost from the mixture. The fresh Cocoa pod husks were chopped into small bits of 5.0 cm breadth and length as outlined by Adegunloye and Olorunnusi (2016) and later mixed thoroughly with the Cow dung by pounding until a homogenous mixture was perceived. The mixture was subsequently put in a self-designed compost container and labeled “composted CPH + CD 1:1 w/w”. The mixture was continuously mixed every five days throughout the 20 days composting period as stated by Vishan *et al.* (2017). Change in temperature of the pile was monitored with the aid of a digital thermometer on a daily basis until the last day of composting. The mixture of the compost was done so as to achieve the release of nutrients gradually through mineralization as reported by Adeleye and Sridhar (2015).

2.4. *Isolation Procedure for Compost Degrading Bacteria*

About Ten (10) grams of compost at the depth of 5.0 cm were collected from the compost pile on the last day of composting out of which 1.0 g each was weighed and suspended into three (3) test tubes containing 9.0 ml sterile distilled water in triplicates. The mixture was vigorously shaken for ten minutes to give room for the formation of supernatant. Subsequently, 1.0 ml of the supernatant was introduced into test tubes (Adeleye and Yerima, 2019) containing Mineral Salt Medium (MSM) prepared according to the prescription of Mukred *et al.* (2008). Cycloheximide (0.2 g /l) was added as antibiotic to all the test tubes to avert the growth of fungi (Vishan *et al.,* 2017). The mixture in the test tubes was then shaken vigorously and allowed to settle. The test tubes were subsequently incubated at 37.0 ^{0}C for four (4) days for bacterial growth as indicated by broth medium turbidity. Bacterial growth observed after incubation was sub-cultured into three (3) test tubes containing Trypticase Soy broth (TSB) and incubated at 37.0 ^{0}C for 48 hours. The TSB was prepared according to the standard procedure described by the manufacturer (Himedia Laboratory Pvt Limited, India). After incubation of the test tubes, further subculturing was carried out using three (3) Trypticase Soy Agar (TSA) plates. The TSA was prepared according to the standard procedure described by the manufacturer

(Himedia Laboratory Pvt Limited, India). The TSA plates were incubated at 37.0 ^{0}C for 48 hours, the colonies that developed were observed and recorded. Eight TSA slants containing pure cultures of the bacterial isolates were subsequently prepared and kept for further tests. Eight (8) distinct bacterial isolates (C_1, C_2, C_3, C_4, C_5, C_6, C_7 and C_8) on the slants were subsequently picked and transferred to other glass slides to form smears. Gram staining procedure was then carried out according to Olutiola *et al*. (1991).

2.5. *Biochemical Tests for the Identification of Bacterial Isolates*

The choices made on the types of biochemical tests conducted on each of the already isolated and gram-stained bacteria in this study were influenced by the procedure prescribed by Barrow and Feltham (1993) for the identification of such groups of bacteria based on their morphological attributes. Biochemical tests were done according to the procedures established by Cheesebrough (2000); Choopun *et al*. (2002); Ochei and Kolhatkar (2008); Wilson (2012); Hemraj *et al*. (2013); Himedia (2015); Pokhrel (2015); Microbeonline (2019).

3. Results and Discussion

3.1 Results

The composting system set up in this study as shown in recorded varying temperature changes as depicted in Fig. 1. In this study, the lowest temperature (32.7^{0}C) of the pile was recorded on the first day while the highest temperature (40.7^{0}C) was recorded on the fourth day of composting. The physicochemical properties of the compost generated on the last day of composting are depicted in Table 1. Having conducted gram staining procedure on the distinct colonies that developed and kept on TSA slants, the following results depicted in Table 2 are recorded.

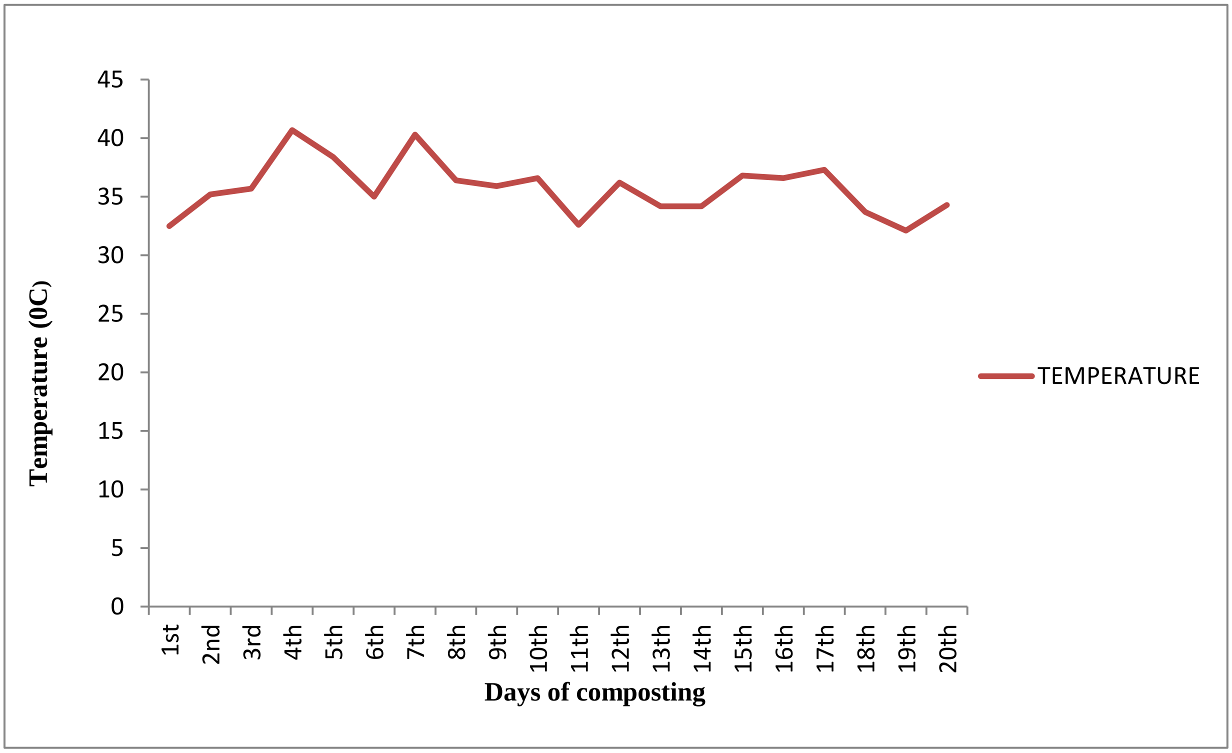

Figure 1: Change in temperature of the composting system

Table 1: Physicochemical Properties of Compost

Parameters	Compost
Moisture content (%)	2.0
Ash content (%)	65
$pH_{(water)}$	9.45
Organic Carbon (%)	48.25
Total Nitrogen (%)	5.85
Available Phosphorous (mg kg^{-1})	1.48
EC (ds cm^{-1})	8.86
Exchangeable Bases (cmol kg^{-1})	
Potassium	213.16
Calcium	4.8
Magnesium	3.24
Sodium	0.5
CEC	221.7

Table 2: Gram reactions of distinct bacterial colonies

Distinct colonies	Gram reactions
C_1	- rods
C_2	+ Cocci (sphere)
C_3	- rods
C_4	- rods
C_5	- rods
C_6	- rods
C_7	+rods
C_8	+rods

KEY: + = Gram positive, - = Gram negative

Apart from C_2 that was detected to be Gram positive cocci (sphere), all other distinct colonies examined under the microscope recorded Gram negative rods ($C_{1,}$ $C_{3,}$ $C_{4,}$ C_5 and C_6) and Gram positive rods (C_6 and C_7) (Table 2). The results of series of biochemical tests conducted in this study are shown in Table 3.

3.2. Discussion

In addition to the thermophiles recorded in the compost pile, the presence of mesophiles that thrive at warmer temperatures between 21 and 32^{0}C reported by Patterson (2019) was witnessed in this study. This author implicated these mesophilic bacteria found at this temperature range as the aerobic powerhouses that effect the decomposition that takes in composting process. The generation of heat in compost piles has been reported by Weston (2019). As recorded in this study, this author reported that the activity of the mespohiles gives rise to heat generation and a significant increase in the temperature of the compost which ultimately favours thermophilic organisms that thrive within a temperature range of 40°C and 70

Key:+Positive,=Negative,-Notdone

. T**able 2: Biochemical characterization of the bacterial isolates**

Characteristics	**C_1**	**C2**	**C3**	**C4**	**C_5**	**C_6**	**C_7**	**C_8**
Gram stain	-	+	-	-	-	-	+	+
Cell shape	Rod	Cocci	Rod	Rod	Rod	Rod	Rod	Rod
Nitrate	-	ND	ND	+	ND	ND	-	+
Catalase	ND	ND	ND	ND	ND	ND	ND	ND
Motility	ND	-	+	+	ND	+	+	ND
Oxidase	+	ND	ND	+	ND	ND	-	-
Citrate	+	ND	+	+	ND	-	-	+
Urease	-	ND	+	-	-	-	ND	-
Casein hydrolysis	-	ND	+	ND	+	-	-	ND
Glucose	-	ND	ND	+	+	ND	+	+
Fructose	-	ND	ND	+	ND	ND	ND	ND
Mannose	ND	ND	ND	ND	ND	ND	+	+
Maltose	-	ND	ND	-	ND	ND	ND	ND
Mannitol	-	ND	ND	ND	ND	ND	ND	ND
Sucrose	-	+	+	-	-	-	ND	ND
Xylose	-	ND	-	+	-	+	+	-
Tyrosine hydrolysis	+	ND	ND	ND	ND	ND	ND	ND
Growth on cetrimide agar	+	ND	ND	ND	ND	ND	ND	ND
Indole	ND	ND	-	ND	+	+	-	-
VogesProskauer	ND	-	+	ND	ND	-	+	+
Galactose	ND	ND	ND	ND	ND	ND	-	+
Growth on 10% NaCl	ND	ND	ND	ND	ND	ND	-	+
Methyl Red	ND	ND	-	ND	-	+	ND	ND
Starch	ND	+	-	ND	-	ND	ND	ND
Lactose	ND	+	-	-	-	ND	ND	ND
Phosphatase	ND	+	ND	ND	ND	ND	ND	ND
Possible bacteria	*Alcaligenes feacalis*	*Streptococcus* sp	*Serratiamarcescens*	*Pseudomonas* sp	*Flavobacterium* sp	*E. coli*	*Bacillus stearothermophilus*	*Bacillus subtilis*

The results recorded on the microscopic characterization of the bacterial isolates in this study suggest that rod shaped bacteria predominantly contributed to the decomposition of the organic materials composted. It can be seen that all the biochemical tests conducted on C_1 indicated that the isolated bacterium is *Alcaligenes feacalis* while the various biochemical tests conducted to identify C_2, C_3, C_4, C_5, C_6, C_7 and C_8 indicated that *Streptococcus* sp, *Serratia marcescen*s, *Pseudomonas* sp, *Flavobacterium* sp, *Escherichia coli*, *Bacillus stearothermophilus* and *Bacillus subtilis* respectively. Similar results have been reported by Andrews *et al.* (1994); Alfreider *et al*. (2002); Gentleman *et al*. (2004); Zaidi *et al*. (2009); Partanen *et al.* (2010); Weston (2019).

Interestingly, a similar study conducted by Adegunloye and Olorunnusi (2016) revealed *Bacillus* sp and *Escherichia coli* as the bacteria that had the highest percentage frequency (11.7%) in the pile of compost investigated. The results obtained in this study have revealed that composting is an aerobic process aided by members of facultative anaerobic bacteria involving *Bacillus* sp. Similar assertions have been reported by De Bertolli *et al.* (1980); Vishan *et al*. (2017).

Conclusion

The method adopted for the isolation of the bacteria responsible for the composting of CPH and CD in this study is effective as eight bacteria were isolated through its adoption. However, the biochemical identification of the bacterial isolates needs confirmation by subjecting the bacterial isolates into molecular identification.

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References

Adegoke, A. A., Awolusi, O. O. and Stenström, T. A. (2016). Organic Fertilizers: Public Health Intricacies. I*ntech*, Chapter 16, pp 343-347.

Adegunloye, D.V and Olorunnusi, T. M. (2016). Production of Compost from Cocoa Pod Wastes and Animal Dung. *Nigerian Journal of Microbiology*, **30** (1): 3184 – 3191.

Adegunloye, D.V., Adetuyi, F.C., Akinyosoye, F.A. and Doyeni, M.O. (2007). Microbial analysis of compost using cowdung as booster. *Pakistan journal of nutrition*, **6** (5): 506-510.

Adeleye, A. O. and Sridhar, M. K. C. (2015).Effects of Composting on Three CPH Based Fertilizer Materials Used for Cocoa Nursery. *The International Journal of Science &Technoledge*, **3** (12): 53-60.

Adeleye, A. O. and Yerima, M. B. (2019). Isolation and Identification of Spent Engine Oil Utilizing Bacteria from Mechanic Village Dutse, Jigawa

State. Paper presented at the 42nd Conference of the Nigerian Society for Microbiology. Crawford University, Igbesa, Ogun State.

Alfreider, A., Peters, S., Tebbe, C. C., Rangger, A. and Insam, H. (2002). Microbial Community Dynamics during Composting of Organic Matter Determined by 16S Ribosomal DNA Analysis. *Compost Sci Util.*, 10 (4): 303–312.

Anastasi, A., Varese, G. C. and Marchisio, V. F. (2005). Isolation and Identification of Fungal Communities in Compost and Vermicompost. *Mycologia*, 97: 33–44.

Andrews, S. A., Lee, H. and Trevors, T. (1994). Bacterial Species in Raw and Cured Compost from a Large-Scale Urban Composter. *J Ind Microbiol.*, 13: 177–182.

Barrow, G. I. and Feltham, R. K. A. (1993). Cowan and Steel's Manual for the Identification of Medical Bacteria. Cambridge University Press 3rd Edition. Pp 52-101. Retrieved from https://www.academia.edu/8106702/Cowan_and_Steels_manual_for_the_identification_of_medical_bacteria_COWAN_AND_STEELS_Manual_for_the_identification_of_medical_bacteria_THIRD_EDITION_EDITED_AND_REVISED_BY. Accessed on July 2nd, 2019.

Bhatia, A., Madan, S., Sahoo, J., Ali, M., Pathania, R. and Kazmi, A. A. (2013). Diversity of Bacterial Isolates during Full Scale Rotary Drum Composting.*Waste Manag.*,**33** (7): 1595–1601.

Cheesebrough, M. (2000). Medical Laboratory Manual for Countries Part 2.2nd edition, University Press Cambridge.

Choopun, N., Louis, V., Huq, A. and Colwell, R. R. (2002). Simple Procedure for Rapid Identification of *Vibrio cholera* from the Aquatic Environment.*Applied and Environmental Microbiology*. Retrieved from https://aem.asm.org/content/68/2/995. Accessed on July 2nd, 2019.

De Bertolli, M., Citernesi, U. and Griselli, M. (1980). Bulking Agents in Sludge Composting. *Compost Sci Land Util.*, 21: 32–35.

Gentleman, R. C., Carey, V. J., Bates, D. M., Bolstad, B., Dettling, M., Dudoit, S., Ellis, B., Gautier, L., Ge, Y., Gentry, J., Hornik, K., Hothorn, T., Huber, W., Iacus, S., Irizarry, R., Leisch, F., Li, C., Maechler, M., Rossini, A. J., Sawitzki, G., Smith, C., Smyth, G., Tierney, L., Yang, J. Y. and Zhang, J. (2004). Bioconductor: Open Software Development for Computational Biology and Bioinformatics. *Genome Biol.*, 5 (10): R80.

Hassen, A., Belguith, K., Jedidi, N., Cherif, M. and Boudabous, A. (2001). Microbial Characterization during Composting of Municipal Solid Waste.*Bioresour Technol.*, **80**: 217–225.

Hemraj, V., Diksha, S. and Avneet, G. (2013). A Review on Commonly Used Biochemical Test for Bacteria. *Innovare Journal of Life Science*, **1** (1): 1-7.

Himedia (2015). Technical Data. Gluconate Test Medium. Retrieved from http://himedialabs.com/TD/M483.pdf. Accessed on July 2nd, 2019.

Jin-Hyunju, Yan-joingseong, Kim-Teong Gap, Jeong-Enusu, Jin-Hj, Yang, J. S. and Jeong-Es. (1996). Application of cattle manure on the soil properties, yield and quality fo silage maize cultivated on paddy land. *Journal of the Korean Society of Grass land Science,* **16**:181-186.

Kutu, F. R., Mokase, T. J., Dada, O. A. and Rhode, O. H. J. (2019). Assessing microbial population dynamics, enzyme activities and phosphorus availability indices during phospho-compost production. International Journal of Recycling of Organic Waste in Agriculture, 8, (1): 87–97.

Martin, D.L. and Gershuny, G. (1992). *The Rodale Book of Composting*.Rodale Press Inc., Emmaus, PA. New, rev. ed. Emmaus, PA: [New York]: Rodale Press; St. Martin's Press.

Mathur, S. P. (1991). Composting Processes. In: Martin A.M. (ed.) Bioconversion of Waste Materials to Industrial Products. Elsevier Applied Science, New York, USA, Pp. 147–183.

Microbeonline (2019). Medical Microbiology Guide. Retrieved from https://microbeonline.com/. Accessed on July 2nd, 2019.

Mukred, A. M., Hamid, A. A., Hamzah, A. and Yusoff, W. M. W. (2008). Growth Enhancement of Effective Microorganisms for Bioremediation of Crude Oil Contaminated Waters. *Pakistan Journal of Biological Sciences*, **11** (13): 1708-1712.

Ochei, J. O. and Kolhatkar, A. A. (2008). Medical Laboratory Science: Theory and Practice. Tata McGraw Publishing Company Limited. Seventh Edition. Pp 820-821.

Oladokun, M. A. O. (1995). Encouraging Domestic Consumption of Cocoa and Cocoa Products in Nigeria. Issues in production, processing and Trade. Proceedings of exhibition and workshop on cocoa held at the Ondo State Trade Fair Complex, Akure, Nigeria. April 19-24, Pp. 30-32.

Olutiola, P. O., Famurewa, O. and Sonntag, H. G. (1991). An Introduction to General Microbiology: A Practical Approach. Hygiene-Institut Der Universitat Heidelberg. Pp. 70-125. ISBN 3-89426-042-4.

Pan, I. and Sen, S. K. (2013). Microbial and Physico-chemical Analysis of Composting Process of Wheat Straw.*Indian J. Biotechol.,* **12**: 120–128.

Partanen, P., Hultman, J., Paulin, L., Petri Auvinen, P. and Romantschuk, M. (2010). Bacterial Diversity at Different Stages of the Composting Process. *BMC Microbiol.*, 10: 94.

Patterson, S. (2019). Compost Enhancing Bacteria: Information on Beneficial Bacteria Found In Garden Compost Composting Basics. Retrieved from https://www.gardeningknowhow.com/composting/basics/compost-bacteria-information.htm.Accessed on July 2nd, 2019.

Pokhrel (2015). Cetrimide Test- Principle, Procedure, Result Interpretation and Limitation.Retrieved from http://microbiologynotes.com/cetrimide-test-principle-procedure-result-interpretation-and-limitation/.Accessed on July 2nd, 2019.

Raymond, W. M. and Roy, L.D. (1992). Organic Matter and Container Media Soils.An Introduction of Soils and Plant Growth. 6th ed. Reprinted by Indian Prentice- Hall Inco. Pp. 181-224.

Ryckeboer, J., Mergaert, J., Vaes, K., Klammer, S., De Clercq, D., Coosemans, J., Insam, H. and Swings, J. (2003). A Survey of Bacteria and Fungi Occurring during Composting and Self-Heating Processes.*Ann Microbiol.,* **53**: 349–410.

Sonia, M. T., Wan, H. C. and Nora, F.Y. T. (2002). Microbial Population Dynamics and Enzyme Activities During Composting. *Compost Science and utilization*, 10 (2): 150-161.

TNAU Agrictech Portal (2009). Organic Farming: Compost. Retrieved from http://agritech.tnau.ac.in/org_farm/orgfarm_compost.html. Accessed on 2nd October, 2019.

Trautmann, N. and Olynciw, E. (1996). Compost Microorganisms. Cornell Composting. Retrieved from http://compost.css.cornell.edu/microorg.html. Accessed on July 2nd, 2019.

Vishan, I., Sivaprakasam, S. and Kalamdhad, A. (2017). Isolation and Identification of Bacteria from Rotary Drum Compost of Water Hyacinth. *Int J Recycl Org Waste Agricult.*, **6**:245–253.

Weston, R. (2019). Carry on Composting: Home and Community Composting. Retrieved from http://www.carryoncomposting.com/416920205. Accessed on July 4, 2019.

Wilson, G. (2012). Virtual Unknown Microbiology Internet Edition. Retrieved from https://www.vumicro.com/vumie/help/VUMICRO/.Accessed of July 15th, 2019.

Zhu, N. (2006). Composting of high moisture content swine manure with corncob in a pilot-scale aerated static bin system. *Bioresource Technology*, **97**(15):1870–1875.