PRODUCTION OF KUNAPAJALA, ITS NUTRITIONAL CONTRIBUTIONS, MICROBIAL AND PESTICIDAL EFFECT

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Abstract

A study on nutritional and microbial analysis of Kunapajala with different storage time interval was conducted in the Department of Soil Science & Agricultural Chemistry and the Department of Plant Pathology, UBKV, Coochbehar-736165, West Bengal during March, 2019. The motive of this work was to estimate the physicochemical properties, macro and micro nutrient content and various microbial load of Kunapajala with different storage time interval. Kunapajala had the highest P, K, Ca, Mg, Fe, Zn, Cu & Mn 40 days after preparation and it had highest N and S 20 days after preparation. It had the highest beneficial microbial load of Fungi, *Actinomycetes*, *Pseudomonus*, Phosphorus Solubilising Bacteria (PSB), *Azotobacter*, *Azospirillum*, *Rhizobium* and *Trichoderma* 40 days after preparation. So, continuous foliar and soil application of Kunapajala from 20 days after preparation to 40 days after preparation was beneficial to get maximum utilization. Moreover, Kunapajala can be used as an alternative against chemical fertilizers and pesticides to develop organic farming.

Key words: Kunapajala, Liquid organic manure, Organic farming, Organic pesticide, Organic fertilizer.

1. Introduction

India faced several famines in its history and these famines claimed millions of lives. In the famine of 1943, India lost around four million lives in eastern India alone (Dyson and Maharatna 1991).To solve that situation and to become self-sufficient in food production, the government of India launched several scientific ventures. Ultimately in late 1960'-s, India became self-sufficient in food through green revolution. The success of green revolution mainly relied on the heavy use of chemical fertilizers, pesticides, high yielding varieties and modern mechanical agricultural instruments (FAO, 2009). In contrast, modernization of agriculture and dependency on chemical fertilizers and pesticides gradually deteriorates the soil fertility and adversely affects the ecological balance, natural biodiversity and environment (Paull, 2011). Adaptation of organic agriculture is the only way to solve this problem (Manna *et al*., 2005). The procedure of preparation of Kunapajala was mentioned in Vrikshayurveda written by Surpala. According to verse 101, 102, 103 and 104 of Vrikshayurveda, it could be prepared by mixing excreta, marrow of the bones, flesh, brain and blood of the boar with water. After that the mixture should be boiled and stored in an iron pot after adding sufficient quantity of husk, sesame oil cake, honey, black gram and ghee. As per availability, the blood, flesh and marrow of fish, goat or other animals could be used for

the preparation. The items should be taken at random, no specific proportion is mentioned. Verse 106 of Vrikshayurveda explained that Kunapajala was highly effective for the crop plants. A significant increase in production was observed due to spraying of Kunapajala in several crop plants including mango (*Mangifera indica*), Soapnut (*Sapindus emarginatus*), Coconut (*Cocos nucifera*), kiwi fruit (*Actinidia deliciosa*) and bringal (*Solanum melongana*). Spraying of Kunapajala on tea bushes controlled the attack of tea mosquito bug (*Helopeltis theivora*) and loopers (*Biston suppressaria*). Narayanan (2006) reported that after spraying Kunapajala (made of rat flesh, Mushika kunapa) rats were totally disappeared from tea garden. So it can also be used as an alternative against chemical pesticides and rodenticides (Ayangarya, 2004a, 2004b, 2005, 2006a, 2006b) (Narayanan, 2006) (Bhat and Vasanthi 2008). Hence, my motive of this research is to observe the physical, nutritional and microbial properties of the Kunapajala with different storage time intervals. Due to several microbial interactions, the nutritional status of Kunapajala is continuously changing. By studying the nutritional content and microbial population, we can understand the potentiality of Kunapajala in different time intervals. According to that proper spraying schedule of Kunapajala should be recommended to the farmers for maximising crop yield.

2. Materials and Methodology

2.1. Preparation of Kunapajala

Ingredient: Bombay Duck fish [*Harpedon nehereus,* cheap, devoid of scales and easily decomposable)(2.5 kg], Powdered sesame oil cake (1 kg), Rice husk (1 kg) , Molasses (1 Kg), Jersey cow urine (7.5 litres).

Procedure: All these ingredients were mixed in an earthen pot, closed the container and allowed them to ferment. Stirring twice in a day should be done in both directions. After 40 days the solution should be filtered and collected (Sarkar *et al*., 2014).

Kunapajala- Fermentation State and liquid extract after filtering

2.2. Nutritional and microbial analysis of Kunapajala

The physical, nutritional and biological parameters of Kunapajala were analysed on the day of preparation (0 days), 20 days after preparation and 40 days after preparation using scientifically approved standard procedures. The standard procedures performed for the estimations of these parameters are described in Table-1 and Table-2.

Table-1. Physical and chemical properties of Kunapajala

Sl. No.	Parameters	Methods	Reference
1	Colour	Visual evaluation	
2	Odour	Sensory evaluation	
3	Mould Growth	Visual evaluation	
4	Maggot Population	Visual evaluation	
5	pH	pH meter method	Jackson (1973)
6	EC	Conductivity meter method	Jackson (1973)
7	Organic Carbon (OC)	Walkley and Black wet digestion	Walkley and Black (1934)
8	Total Nitrogen	Microkjeldhal method	Jackson (1973)
9	Total Phosphorus	Nitric-Perchloric(9:4) digestion and colorimetry using vanado-molybdo phosphoric yellow colour method	Jackson (1973)
10	Total Potassium	Nitric-perchloric(9:4) digestion and flame photometry	Jackson (1973)
11	Total Calcium	Nitric-perchloric(9:4) digestion and AAS	Jackson (1973)
12	Total Magnesium	Nitric-perchloric(9:4) digestion and AAS	Jackson (1973)
13	Total Sulphur	Nitric-perchloric(9:4) digestion and Turbidimetry	Massoumi and Cornfield (1963)
14	Total Micronutrients Fe, Mn, Zn ,Cu	Nitric-perchloric(9:4) digestion and AAS	Jackson (1973)

Table-2. Biological properties of Kunapajala

Sl. No.	Parameters	Methods	Reference
1	Bacteria	Nutrient Agar medium	Atlas and Parks (1993)
2	Fungi	Martin's rose Bengal Agar	Martin (1950)
3	*Actinomycetes*	Ken knight's Agar medium	Cappuccino and Sheman (1996)
4	PSB	Pikovskaya's medium	Sundararao (1963)
5	*Azospirilum*	Nitrogen free Bromothymol blue medium	Dobereiner *et al*.,(1976)
6	*Azotobacter*	Jensen's medium	Jensen (1942)
7	*Trichoderma*	Trichoderma specific Medium	Saha and Pan (1997)
8	*Pseudomonus*	King's B Agar medium	King *et al*.,(1954)
9	*Rhizobium*	Yeast extract Mannitol Agar with Congo red	Fred *et al*.,(1932)

3. Results and Discussion

Table-3. Physical and Physico-chemical parameters of Kunapajala

KUNAPAJALA			
Parameters	**On the day of preparation (0 days)**	**20 days after preparation**	**40 days after preparation**
Colour	Light brownish orange	Brownish orange	Dark brownish orange
Odour	Mild alcoholic smell	Foul alcoholic smell	Extreme foul alcoholic smell
Mould growth	No mould growth	Heavy mould growth	No mould growth
Maggot Population	No maggot found	Heavy maggot growth	No maggot found
pH	6.74	3.47	8.81
EC (ds/m)	2.55	9.72	8.57
Total OC (%)	1.72	2.55	4.18

The colour of freshly prepared Kunapajala was brownish orange then it became darker from the 20th day onwards. Through anaerobic respiration, several gases were produced and that cause natural liquids and liquefying tissues. They also caused build-up of pressure combined with the loss of integrity of the skin and ultimately the tissue was ruptured. Ruptures in the skin allowed oxygen to re-enter the tissue and provide more surface area for the development of fly larvae and the activity of aerobic microorganisms. For these activities dark brownish orange colour was developed (Janaway *et al*., 2009; Carter *et al*., 2008).

Fresh preparation of Kunapajala possessed a foul alcoholic smell. Extreme foul odour was observed from 20 to 40 days onwards. Foul alcoholic odour was developed due to putrefaction. Anaerobic metabolism took place, leading to the accumulation of gases, such as hydrogen sulphide, carbon dioxide, methane, cadaverine, putrescine and nitrogen. The purging of gases and fluids resulted the strong distinctive odours (Carter *et al*., 2008; Payne, 1965).

Initially there was no mould growth in Kunapajala whereas it was first observed 5 days after preparation. Mould growth was observed on the liquid surface and also on the sides of the storage vessel from the 15th day onwards, the decrease in mould growth was observed in the 20th day and was completely absent in the 25th. Fungi consumed energy or food from the decaying tissue and enhanced the decomposition process. Fungi were abundant in the environment. Through air or from any other source they might be appeared in the Kunapajala vessel, but when tissues became totally liquefied or almost decomposed their population started declining. It was due to unavailability of food from that decaying tissue (Hawksworth and Wilthshire 2011) (Schwarz *et al*., 2015) (Hitosugi *et al*., 2006).

During decomposition, at initial stages Kunapajala attracted flies and these flies which laid eggs on it. From those eggs maggots were developed. Young maggots spread throughout the container and took food from the decaying tissue. Due to the activity of maggots the tissue

started decomposing faster and the bacterial activity also enhanced. This was the reason behind the high development of maggots in Kunapajala after 5 days of its preparation. After 25 days of its preparation due to the loss of readily available cadaveric material, maggot population drastically reduced (Anderson, 2000), (Fuller, 1934) (Morovic-Bodac, 1965), (Carter and Tibbett 2008), (Janaway *et al*., 2009)

On the day of preparation Kunapajala showed pH (6.74) and after 20 days it became highly acidic in nature (3.47). Then after 40 days it became alkaline in nature (8.81). Animal tissue decomposition initially created an alkaline environment and due to microbial activity it became acidic after 20 days. When decomposition was totally completed, it became alkaline again (Carter, 2005; Hopkins *et al*., 2000; Rodriguez and Bass 1985) (Gill-King, 1997; Towne, 2000). Similar results were also found by Anandan *et al*., (2016), Jani *et al*., (2017) and Ankad *et al*., (2017) in Kunapajala.

Kunapajala showed highest EC 20 days after preparation (9.72 ds/m) due to high acidic nature of the solution and after that it started declining (8.57 ds/m, 40 days after preparation). On the day of preparation it showed the lowest EC (2.55 ds/m) (Carter, 2005; Hopkins *et al*., 2000; Rodriguez and Bass 1985) (Gill-King, 1997; Towne, 2000). Anandan *et al*.,(2016) and Ankad *et al*.,(2017) also concluded similar trend and results.

Total OC (organic carbon) was highest 40 days after preparation (4.18%) and on the day of preparation it showed minimum value (1.72%) in Kunapajala. In decomposition physical breakdown and biochemical transformation of complex organic molecules occurred, due to that several organic carbon compounds were synthesized (Juma, 1998). This was the reason for continuous increase of OC in Kunapajala. Anandan *et al*., (2016) noticed similar trend of OC and results in his experiment.

Physical and physicochemical parameters of Kunapajala were mentioned in Table-3.

The highest N content was recorded 20 days after preparation in Kunapajala (7238 mg/dm^3) while on the day of preparation it recorded the lowest value (3486 mg/dm^3). For the activity of bacteria and maggots, Kunapajala started decomposing faster and due to that N content of the Kunapajala was in an increasing trend, but after 20 days 9-44% of the N was volatized in the form of Ammonia from the solution due to alkalinity of the Kunapajala solution at that moment (Kirchmann and Witter 1989). Ankad *et al*., (2017) and Jani *et al*., (2017) also concluded similar trend and results in their experiment.

On the day of preparation Kunapajala recorded the lowest value (208.661 mg/dm^3) of P, while after 40 days of preparation it recorded the highest value (517.717 mg/dm^3) of P. Kunapajala contained animal tissue which had high P content. According to Tian *et al*., (1995), organic matters high in P decompose faster and release P significantly. So, Kunapajala had increasing trend of P content during decomposition. Ankad *et al*., (2017) and Jani *et al*., (2017) also analysed the P content of Kunapajala and found similar results.

K content was lowest on the day of preparation (890.396 mg/dm^3), after that it was gradually increased and reached the highest value 40 days after preparation (1873.543 mg/dm^3).

Activity of fungi and other microorganisms was the reason behind continuous release of K up to 40 days (Carter *et al*., 2007).

The highest Ca content was observed 40 days after preparation (614 mg/l) and on the day of preparation it was the lowest (376 mg/l). Excessive fungus and microbial activity was the reason for continuous release of Ca up to 40 days (Carter *et al*., 2007).

On the day of preparation Mg content was the lowest (56 mg/l) whereas after 40 days it recorded the highest value (88 mg/l). Fungal and microbial activity was the main cause behind gradual release of Mg in Kunapajala (Carter *et al*., 2007).

S content was the lowest on the on the day of preparation (678 mg/l), whilst 20 days it recorded the highest value (857 mg/l), then S content started declining. Due to excessive volatile release of hydrogen sulphide, after 20 days S content started declining (Carter *et al*., 2007).

The highest Fe content was recorded 40 days after preparation (72 mg/l) while on the day of preparation it was the lowest (55 mg/l). Due to fungal and bacterial activity gradual release of Fe was noticed in Kunapajala (Dent *et al*., 2004).

On the day of preparation Zn content was minimum (6.78 mg/l) while 40 days after preparation it became maximum (17.75 mg/l). Gradual increase of Zinc content was noticed in Kunapajala due to activity of fungi and bacteria (Hodson *et al*., 2001, Kearney *et al*., 2000 and Deydier *et al*., 2005).

Cu content was maximum 40 days after preparation (8.53 mg/l) and on the day of preparation it recorded the lowest value (4.76 mg/l). Continuously increasing trend of Cu content was observed due to activity of several fungal and bacterial species (Hodson *et al*., 2001, Kearney *et al*., 2000 and Deydier *et al*., 2005).

The highest Mn content was noticed 40 days after preparation (2.06 mg/l) and on the day of preparation the Mn content recorded the lowest value (0.58 mg/l). Heavy microbial interaction or activity inside Kunapajala might be the reason of this trend and result.

The macro and micro nutrient content of Kunapajala was mentioned in Table-4.

Table-4. Macro and micro nutrient content of Kunapajala

KUNAPAJALA			
Parameters	**On the day of preparation (0 days)**	**20 days after preparation**	**40 days after preparation**
N mg/dm^3	3486	7238	4690
P mg/dm^3	208.661	296.260	517.717
K mg/dm^3	890.396	1589.994	1873.543
Ca (mg/l)	376	452	614
Mg (mg/l)	56	73	88
S (mg/l)	678	857	719
Fe (mg/l)	55	67	72

Zn (mg/l)	6.78	13.63	17.75
Cu (mg/l)	4.76	7.44	8.53
Mn (mg/l)	0.58	1.27	2.06

Fungi population was the highest 40 days after preparation (33 x 10^8 cfu/ml) and it was the lowest on the day of preparation (4 x 10^4 cfu/ml). This gradual increasing trend was noticed due to enhanced activity of early stage fungi *ascomycetes*, *deuteromycetes* and saprophytic *basidiomycetes* and late stage fungi ectomycorrhizal *basidiomycetes* in Kunapajala with time (Carter and Tibbett 2003).

On the day of preparation Kunapajala recorded the lowest *Actinomycetes* population (3 x 10^3 cfu/ml). After that it increased continuously and reached the highest 40 days after preparation (5 x 10^8 cfu/ml). Continuous decomposition of complex mixture of polymers in dead animal tissues was the prime reason for continuous development of *Actinomycetes* population in Kunapajala (Goodfellow and Williams 1983, McCarthy and Williams 1992, Stach and Bull 2005).

The highest population of *Pseudomonus* was noticed 40 days after preparation (13 x 10^{10} cfu/ml) in Kunapajala while on the day of preparation it recorded the lowest (5 x 10^3 cfu/ml). This type of increasing trend up to 40 days in Kunapajala was also concluded by Ali (2012).

PSB population was the highest on the day of preparation (2 x 10^5 cfu/ml) then it became maximum at 40 days after preparation (21 x 10^{10} cfu/ml) in Kunapajala. Similar trend of population growth was also observed by Ali (2012) in Kunapajala.

On the day of preparation *Azotobacter* population had the lowest value (7 x 10^4 cfu/ml) in Kunapajala while after 40 days it became the highest (13 x 10^{12} cfu/ml). Presence of *Azotobacter* in Kunapajala and this type of growth trend was justified by Ali (2012).

The highest *Azospirilum* population was noticed 40 days after preparation (13 x 10^{10} cfu/ml) and on the day of preparation the lowest value was found (11 x 10^3 cfu/ml). Ali (2012) approved the existence and growth behaviour of *Azospirilum* in Kunapajala.

The lowest *Rhizobium* Population was found on the day of preparation (2 x 10^3 cfu/ml) and after 40 days, the highest Rhizobium population (4 x 10^{11} cfu/ml) was noticed in Kunapajala. Ali *et al*., (2012) also concluded similar trend of population growth of *Rhizobium* in Kunapajala.

Trichoderma population was highest 40 days after preparation (21 x 10^8 cfu/ml) in Kunapajala and on the day of preparation it had the lowest population (6 x 10^3 cfu/ml). *Trichoderma* had significant contribution in decomposition and biodegradation of organic matters and due to that the population of *Trichoderma* in Kunapajala had a continuous increasing trend up to 40 days (Woo *et al*., 2014).

Microbial population of Kunapajala was mentioned in Table-5.

Table-5. Microbial population of Kunapajala

KUNAPAJALA			
Parameters	**On the day of preparation (0 days)**	**20 days after preparation**	**40 days after preparation**
Fungi (cfu/ml)	4×10^4	16×10^7	33×10^8
Actinomycetes(cfu/ml)	3×10^3	6×10^4	5×10^8
Pseudomonus (cfu/ml)	5×10^3	8×10^{10}	13×10^{10}
PSB(cfu/ml)	2×10^5	15×10^{10}	21×10^{10}
Azotobacter (cfu/ml)	7×10^4	9×10^{12}	13×10^{12}
Azospirilum (cfu/ml)	11×10^3	8×10^8	13×10^{10}
Rhizobium (cfu/ml)	2×10^3	6×10^6	4×10^{11}
Trichoderma (cfu/ml)	6×10^3	18×10^8	21×10^8

4. Conclusion

The study concludes that Kunapajala has high nutrient content and beneficial microbial population. Nutrient content of Kunapajala is highly influenced by its microbial population. Fungi will help to breakdown complex organic compounds and produce simple organic and inorganic compounds useful for plants. *Azotobacter*, *Azospirilum* and *Rhizobium* help to fix more N in crop field. PSB enhance the P solubilisation in crop field. *Actinomycetes* help to decompose complex organic molecules and antagonistic potential of *Pseudomonus*, while *Trichoderma* will help to protect the crop from soil-borne diseases. Microbial population is continuously increasing and it became the highest after 40 days. So, application of Kunapajala after 40 days is beneficial for crops, but N and S content of Kunapajala is the highest 20 days after preparation, so to exploit that spraying of Kunapajala after 20 days is also recommended. Spraying of Kunapajala on the day of preparation is not recommended because the microbial population and nutrient content is the minimum and most of the organic matter is not properly decomposed, so they will not be highly available for the cop plants. So foliar and soil application of Kunapajala from 20 days of its preparation to 40 days of its preparation is recommended for the crop and soil because we can utilise its total potential. The ingredients required to prepare it are easily available and cheap comparing with chemical fertilizers and pesticides. The crops produced using Kunapajala will be free from any harmful chemical residues. So, it is healthy for the consumer. Moreover use of Kunapajala instead of chemical fertilizer and pesticide is highly useful to increase the crop yield, soil productivity and farmer's income.

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6. References

Ali, M. N., 2012. Sustainable Agriculture with Low Cost Technologies (SALoCT). A project funded by Rural Technology action Group – Eastern India (RuTAG-EI), IIT Kharagpur, under DST, Govt. of India.

Anandan, R., Priya, L. and Rajendran, P., 2016. Dynamics of Organic Biofertilizers on *Oryza sativa* ADT-43. *Int. J. Curr. Microbiol. App. Sci*, **5**(4): 902-908.

Anderson, G. S., 2000. Minimum and maximum development rates of some forensically important Calliphoridae (Diptera). *Journal of Forensic Sciences*, **45**:824-832.

Ankad, G. M., Hiremath, J., Patil, R.T and Pramod, H.J., 2017. Nutrient analysis of Kunapajala and Panchagavya and their evaluation on germination of Ashwagandha (*Withania somnifera Dunal.*) and Kalamegha (*Andrographis paniculata Nees*) seeds: a comparative study. Journal of Ayurveda and Integrative Medicine, **xxx**: 1-7.

Atlas, R. M. and Parks, L. C., 1993. Handbook of microbiological media, *CRC Press, Inc*. London, 529p.

Ayangarya, V. S., 2004a. Herbal kunapa. *Asian Agri-History,* **8**:315–317.

Ayangarya, V. S., 2004b. Manujala: A liquid manure. Asian Agri-History **8**:319–321.

Ayangarya, V. S., 2005. INDSAFARI – An organic pesticide for tea. *Asian Agri-History*, **9**:317–319.

Ayangarya, V. S., 2006a. Mushika kunapa. *Asian Agri-History*, **10**:157–159.

Ayangarya, V. S., 2006b. Kiwifruit plant treatment on the Himalayas of India: A Vrikshayurveda experience. In: Bridging Gap Between Ancient and Modern Technologies to Increase Agricultural Productivity: Proceedings of the National Conference held from 16-18 December 2005, Central Arid Zone Research Institute, Jodhpur 342 003, Rajasthan, India. (Choudhary, S.L., Saxena, R.C., and Nene, Y.L., eds.). Asian Agri-History Foundation, (AAHF), Secunderabad, India; and Rajasthan Chapter of AAHF, Udaipur, India. 2006. pp. 102-103.

Cappuccino, J. G. and Sheman, N., 1996. Microbiology – A Laboratory Manual, 4th ed. *The Benjamin/ Cummings Publishing Company., Inc*., Menlo park, California. pp. 13-182.

Carter, D. O., Yellowlees, D. and Tibbett, M., 2007. Cadaver decomposition in Terrestrial Ecosystems. *Naturwissenschaften*, **94**(1): 12-24.

Carter, D., 2005. Forensic taphonomy: Processes associated with cadaver decomposition in soil. Ph.D. thesis, James Cook University, Townsville, Australia.

Carter, D.O. and Tibbett, M., 2008. Cadaver Decomposition and Soil: Processes". In M. Tibbett; D.O. Carter (eds.). *Soil Analysis in Forensic Taphonomy*,CRC Press. pp. 29–51.

Carter, D. O., and Tibbett, M., 2003. Taphonomic mycota: fungi with forensic potential, *Journal of Forensic Sciences*, **48**(1): 1-4.

Dent, B. B., Forbes, S. L., Stuart, B. H., 2004. Review of human decomposition processes in soil. *Environmental Geology*, **45**(4): 576-585.

Deydier, E., Guilet, R., Sarda, S. and Sharrock, P., 2005. Physical and chemical characterisation of crude meat and bone meal combustion residue: "Waste or raw material?" *Journal of Hazardous Materials*, **121**(1-3): 141–148.

Dobereiner, J., Marriel, I. E. and Nery, M., 1976. Ecological distribution of Spirillum lipoferum, Beijerinck. *Can. J. Microbiol*., **22**: 1464- 1473.

Dyson, T. and Maharatna, A., 1991. Excess mortality during the Bengal famine: a re-evaluation. *Indian Economic and Social History Review*, pp-281-297.

FAO., 2009. Rapid growth of selected Asian economies. Available from http://www.fao.org/docrep/009/ag087e/ AG087E05.htm.

Fred, E. B, Baldwin, I. L. and McCoy, F., 1932. Root Nodule Bacteria and Leguminous Plants. *University of Wisconsin Press*, Madison, Wisconsin.

Fuller, M. E., 1934. The insect inhabitants of carrion: A study in animal ecology. *Council for Scientific and Industrial Research*, Bulletin No.-82, pp-63.

Gill-King, H., 1997. Chemical and ultrastructural aspects of decomposition. *Forensic Taphonomy: The postmortem fate of human remains*, 93–108.

Goodfellow, M. and Williams, S. T., 1983. Ecology of Actinomycetes. *Annual Review of Microbiol.* **37**: 189-216.

Hawksworth D.L. and Wilthshire, P. E. J., 2011. Forensic mycology: the use of fungi in criminal investigations. *Forensic Sci Int* , **206(1-3)**:1-11.

Hitosugi, M., Ishii, K., Yaguchi, T., Chigusa, Y., Kurasa, A., Kido, M., Nagai, T., Tokudome, S., 2006. Fungi can be a useful forensic tool. *Leg Med*, **8**:240- 242.

Hodson, M. E., Valsami-jones, E., Cotter-howells, J. D., Dubbin, W. E. and Kemp, A. J., 2001. Effect of bone meal (calcium phosphate) amendments on metal release from contaminated soils - a leaching column study. *Environmental Pollution*, **112**:233–243.

Hopkins, D. W., Wiltshire, P. E. J. and Turner, B. D., 2000. Microbial characteristics of soils from graves: An investigation at the interface of soil microbiology and forensic science. *Appl. Soil Ecol*. **14**: 283–288.

Jackson, M. L., 1973. *Soil Chemical Analysis*. (*Prentice Hall of India Pvt. Ltd*, New Delhi) pp.183-204.

Janaway, R. C., Percival, S. L. and Wilson A.S., 2009. "Decomposition of Human Remains". In Percival, S.L. (ed.). *Microbiology and Aging*. *Springer Science + Business*. pp. 13–334.

Jani, S., Prajapati, P.K., Harisha, C.R and Patel, B.R., 2017. Kunapajala liquid organic manure: Preparation and its quality Parameters. *World Journal Of Pharmacy and Pharmaceutical Sciences*, Volume **6**:1989-2000.

Jensen, H. L., 1942. Nitrogen fixation in leguminous plants. General characteristics of root nodule bacteria isolated from species of Medicago and Trifolium in Australia. *Proc. Linn. Soc. N.S.W*. **66**:98-108.

Juma, N.G., 1998. The pedosphere and its dynamics: a systems approach to soil science. Volume 1. Edmonton, Canada, *Quality Color Press Inc*. 315 pp.

Kearney, T., 2000. Remediation of Toxic Metal Pollution in Soil Using Bone meal Amendments. *Environment Agency*.

King, E.O., Ward, M.K., Raney, D.E., 1954. Two simple media for the demonstration of payociamin and fluorescein. *J. Lab. Clin. Med*., **44**: 301-307.

Kirchmann, H and Witter, E., 1989. Ammonia Volatilization during aerobic and anaerobic manure decomposition. *Plant and Soil*, **115(1)**:35-41.

Manna, M. C., Swarup, A., Wanjari, R. H., Ravankar, H. N., Mishra, B., Saha, M. N., Singh, Y. V., Sahi, D. K., Sarap, P. A., 2005. Long-term effect of fertilizer and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India. *Fields Crop research*, **93**(2-3), 264-280.

Martin, J. P., 1950. Use of acid, rose bengal, and streptomycin in the plate method for estimation soil fungi. *Soil Sci*. **69(3)**: 215-232.

Massoumi, A. and Cornfield, A. H., 1963. A rapid method for determining sulphate in water extracts of soils. *The Analyst*. **88**: 321–322.

McCarthy, A. J. and Williams, S. T., 1992. Actinomycetes as agents of biodegradation in the environment- *a review. Gene*, **115**: 189-192.

Morovic-Budak, A., 1965. Experiences in the process of putrefaction in corpses in buried in earth. *Medicine, Science and the Law*, **5(1)**:40-43.

Paull, J., 2011. Nanomaterials in food and agriculture: the big issue of small matter for organic food and farming. In: *3rd Scientific Conference of International Society of Organic Agriculture Research*, Namyangju, Korea, **2**:96-99.

Payne, J. A., 1965."A summer carrion study of the baby pig *(Sus scrofa Linnaeus)*". *Ecology*, **46** (5): 592–602.

Rodriguez, W. C. and Bass, W. M., 1985. Decomposition of buried bodies and methods that may aid in their location. *J. Forensic Sci.* **30**: 836–852.

Saha, D. K. and Pan, S., 1997. Qualitative evaluation of some media of Trichoderma and Gliocladium spp. *J. Mycopathol. Res.,* **35**: 7-14.

Sarkar, S., Kundu, S.S. and Ghorai, D., 2014. Validation of ancient liquid organics-Panchagavya and Kunapajala as plant growth promoters. *Indian Journal of Traditional Knowledge*. Vol:**13**(2), pp-398-403.

Schwarz, P., Dannaoui, E., Gehl, A., Felkse-Zech, H., Birngruber, C. G., Dettmeyer, R. B., Verhoff, M. A., 2015. Molecular identification of fungi found on decomposed human bodies in forensic autopsy cases. *Int J Legal Med*, **129**:785-791.

Stach, J. E., and Bull, A. T., 2005. Estimating and comparing the diversity of marine Actinobacteria. *Antonie van Leeuwenhoek*, **87**: 3-9.

Sundararao, W. V. B., 1963. Phosphate dissolving organisms in the soil and the rhizosphere. *Indian J. Agr. Sci*. **33**: 272-278.

Tian, G., Brussaard, L., and Kang, B. T., 1995. An index for assessing the quality of plant residues and evaluating their effects on soil and crop in the (sub-) humid tropics. *Applied Soil Ecology,* **2(1)**:25-32.

Towne, E. G., 2000. Prairie vegetation and soil nutrient responses to ungulate carcasses. *Oecologia*, **122(2)**: 232–239.

Walkley, A. and Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*. **37(1)**: 29-38.

Woo, S. L., Ruocco, M., Vinale, F., Nigro, M., Marra, R. and Lombardi, N., 2014. Trichoderma based products and their use in Agriculture. *The open Mycology Journal*, **8**(1): 71-126.