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Tea leaf waste- a potential source of low-cost compost alternative for kitchen gardening and nursery management

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Abstract
The Tea waste generated after popular Indian Tea beverage preparation is plant-based biodegradable waste which is due to lack of awareness; usually being dumped in the green waste bins. It is thus added into the Municipal waste and collected at landfills. The improper decomposition thereby can lead to production of greenhouse effect promoting gases such as Methane. Instead, the Tea waste can be recycled at home to convert it into the nutrient rich compost product by following few easy steps. This way it can reduce the unnecessary waste accumulation at landfill areas and the compost product can be used for home gardening, kitchen gardening practice and also can be used by local nursery holders.
The purpose of the above study was to reduce the biodegradable waste collection, awareness generation and to convert it in to the free of cost Compost Fertilizer to implement it in to gardening practices and to add on the hobby of Kitchen gardening herb and vegetable cultivation best practices. The product can also be utilised for Organic Farming practices. Thus, considering the above-mentioned positive aspects in to the consideration; present research work was initiated following controlled conditions to prove the benefits in the scientific way. The decomposed organic matter by means of aerobic decomposers converts it into a crumbly textured humus material which possess better water holding capacity, acts as a soil conditioner, promotes growth of beneficial soil microflora and helps in slow release of nutrients to plant roots. In addition, the humus itself is a good fertiliser to the plants and can be easily used as a mulching material on soil surface.
The broad outcome of the above research study includes the reduction of biodegradable waste generation and indirectly reducing the generation of GHG (Greenhouse gas) and to convert the nonedible product into the usable compost by subsequently promoting the idea of home gardening to beautify the home space and also to cultivate edible vegetable crops for plant lovers and promote the idea of Kitchen gardening and Prakrutik kheti.

Keywords: Compost, mulching, humas, water holding capacity, soil microflora, organic farming

Introduction

a. Importance and Need of Composting:

1. Agricultural Residue Accumulation:

Worldwide the plant-based waste especially agricultural residues are big issue as they take longer time to naturally get decompose and further added to the field to replenish the soil nutrients [7, 8]. Farmer often faces the difficulties to properly remove and get rid of such wastage from their field so that they can start next cropping [11]. Scientific community has sincerely worked on these issues and suggested quick decomposition methods such as piling of waste, spreading the beneficial waste decomposer liquid culture to boost the faster decomposition by rapid growth of desired microorganism [1]. Aeration the shuffling of pile is required to ensure aeration and to release excess heat generated due to activity of microorganisms. Occasional sprinkling of water should be performed to retain the presence of microbes eg. NCofF. Waste Decomposer Microbial Consortia formulations have been developed by various Agriculture related research institutes containing Lignolytic and Cellulolytic microbes [4]. Microbes secrete extracellular enzymes like Cellulases, Amylases, Ligninases etc. to digest complex compounds into simpler molecules [6]. Some are isolated from the cow dung residues and provided to the farmers in a small bottle which can be multiplied on jaggery and gram flour mixture in a water barrel to make 200 ml of inoculum for field application. The leachate generated during the decomposition can be supplied to the field to avail dissolved mineral to the growing plants.

2. Urban area and Domestic Green Waste:

Apart from the global level agricultural waste disposal issue there is also a frequent urban issue exists to appropriately dispose the dry garden plant waste, plant trimmings, kitchen green waste and daily generated Tea leaf waste or used Chai patti. These are biodegradable in nature and if appropriate steps are followed; then it does not harm the environment and recycled in such a way that they can be used further as a soil nourishing compost and sustain our ecosystem without addition of any synthetic chemical fertilizers. They possess several benefits and eco-friendly in nature [5]. Because of these; the decomposed biological waste can also be used in the Organic Farming practices and domestically for Kitchen Gardening.

b. Aerobic Decomposer Microorganisms

Various fungal strains such as Trichoderma harzianum, T. viride, Aspergillus niger, A. fumigatus etc. and bacterial strains like Bacillus subtilis, Pseudomonas fluorescens, Streptomyces griseus etc. are of aerobic nature and effectively participates in the decomposition of Plant wastes. They release enzymes to breakdown Cellulose, Lignin, Pectin, Tannin etc. and by rapid multiplication; occupies the waste material and enhances the decomposition process.

c. Tea Plant, Tea Beverage and Disposal of used Chai Patti/ Tea Leaves

Camellia sinensis, Family: Theaceae, commonly known as Tea plant; is globally famous beverage consumed as a refreshing drink. The tea of commerce is prepared after collecting the young leaves of the plant and allowed it to ferment and dry to develop distinct flavor and fragrance.

After brewing approximately 50-100 gm Tea dust waste per household is being daily generated; which does not have any other edible value and usually got disposed off in domestic Green-waste bins and ultimately being dumped in the local landfills. Although it's a biodegradable in nature; but this way it does not benefit the environment and often promotes growth of unwanted saprophytic microorganisms.

One of the possible sustainable uses of this everyday waste is to convert it into an eco-friendly and valuable Compost fertilizer. This practice not only reduces the waste collection at landfills but also prepares a useful organic fertilizer for home and Kitchen gardening practices.

d. Compost Preparation from Tea Waste

Every Indian household generally everyday prepares Tea, which is famous, tasteful beverage and contains medicinal benefits along with Central nervous system stimulant effect. Tea due to its Alkaloids Caffeine along with Theophylline and Theobromine content; decreases fatigue, improvises alertness, and stimulates mental energy. Also, L-Theanine present in Tea promotes relaxation. The flavour, aroma of Commercial Tea products gets extracted during the Tea brewing process and the leftover remained after the process are just the waste and it does not possess any edible and nutritional values.

As the leftover waste at a domestic and commercial level being disposed off in dustbin and it gets collected by the Municipal Waste collection system as Biodegradable Solid waste and dumped at landfills; which does not contribute any beneficial effect to the Environment. Although it's a bio-degradable waste; it does not significantly contribute to the betterment of environment. In many cases; growth of other types of harmful decomposer microflora on the biological waste; increases and often responsible to release GHG (Greenhouse gas) Methane during the process. Instead, if the tea waste is appropriately processed to convert it into Compost; it can be further added to the plants in garden soil or to the potted plants to provide them the benefits of free of cost natural fertilizer without using hazardous Synthetic chemicals. People with Gardening hobby or ladies interested in Kitchen Gardening practice can get benefits of this practice to incorporate healthy nutrients to the Garden plants and to avoid excess of waste generation by implementing simple compost making steps.

Tea waste can be easily converted in to Compost fertilizer by implementing simple steps at home and thereby potted as well as garden plants availed with healthy nourishment without disturbing beneficial microflora of soil and any addition of Synthetic Chemicals. This idea of Tea waste Compost can be advantageous at domestic gardening, large nursery, raising plant beds in agricultural activities and for the bioremediation and revival of the nutrient poor and degraded soils.

As above concept is not explored in terms of standardising decomposition protocol for Tea waste, and benefits received by the plants upon addition within soil. Thus, a scientific approach is been implemented to this concept; by establishment of standardised process and further, plant growth experiments were conducted on different seasonal plants. The action plan was prepared to successfully execute the idea. For this, first priority included was to prepare Compost from collected Tea waste using suitable method which can be easily applied in-home space by a common people without involving much resources. Compost formation involves decomposition by naturally availed decomposer microflora, later humification, and mineralization process.

The biological decomposition of green waste usually includes major actions like Degradation and Digestion of organic matter by growth and enzyme secretion by microorganisms [9]. Later the digested material slowly converts in to structurally simple components and releases stored minerals [2, 3]. These materials easily penetrate and absorbed in the soil and get availed by the soil micro flora and plant roots (Table 1). The digested material is now a remanent and broken pieces of the organic material and works as a spongy, porous, light weight, and serves as soil conditioner. It promotes positive biological activities within soil and plant roots can easily expand in such soft textured aerated soil layer.

Table 1: Compost Making Biological Process

No.	Action	Mechanism/ Activity
i)	Degradation	Microbes secrete extracellular enzymes like Cellulases, Amylases, Ligninases etc. to digest complex compounds into simpler molecules.
ii)	Mineralization	Oxidation of organic Carbon into simpler, stable inorganic compounds adds absorbable minerals.
iii)	Humification	Conversion of organic matter into stable humus.

e. Kitchen Gardening and Nursery Management

Urban space is often occupied by the solid infrastructures and green vegetation space slowly decreasing due to lack of enough space surrounding houses or common spaces. Common issues like busy work life creates a mental stress besides the vegetables and fruits available in market are often cultivated using synthetic fertilizers and chemicals causes health issues [10]. Thus, sensitised people develop a hobby of home gardening and cultivates flowering and seasonal plants. Few people also grow seasonal herbs, and vegetable plants in their front or backyard or on terrace area along with regular gardening referred as Kitchen Gardening. Herbs like Coriander, Mint, Rosemerry, Sage, Oregano, Basil can be cultivated in rectangular pots. Vegetables like Spinach, Onion, Garlic, Turmeric, Carrot, Raphanus, Turnip, Sweet Potato, Cauliflower, Cabbage, Tomato, Chilli, Capsicum, Brinjal, Ladies finger, Pea, Beans, Cucurbits etc. can be easily cultivated in Pots or Garden spaces. Such activity relives from daily mental stress as the cultivating plants gives positivity, can be performed in free time, engages the mind in routine gardening activities, provides yield of necessary herbs and vegetables and also helps in pollution control.

Materials and methods

a. Compost Preparation from Tea Waste

Tea leaf waste generated after the preparation of refreshing Tea Beverage is used to make a compost during the present work. The process, necessary care and steps involved were recorded to suggest an easy, fast and low-cost method to convert the tea waste in to a useful compost. Considering the amount of raw material that is used tea waste; two methods were tested. For the sufficient amount of waste procured from tea stalls; Bulk method can be used. For recycling of domestic low amount of tea waste; Subsequent Collection method can be used.

1. Bulk Method

The used tea waste was utilised to prepare the Compost during the present work. In order to get sufficient quantity; the tea waste was collected from the local tea vendor stall. Then, to remove the milk residues; it was washed two to three times using normal tap water. After draining excess of water; the washed tea waste was allowed to semi dry by spreading on the garden area.

In the next step; the washed tea waste was collected and filled in the 12 inch size clay pots, covered with cardboard sheet and kept in a cool shady area for the decomposition. The compost filled pots were regularly monitored for the temperature and humidity. The raw material humidity during the decomposition process was maintained in the range of 80 to 90 % by spraying water (Fig 1).

Also, intermittent mixing of the clay pot filled tea leaf waste was performed to promote aeration in to the deep layers and growth of decomposer microbes. The temperature, internal humidity/ moisture data was collected using HASTHIP high precision dual pin LCD Soil moisture sensor digital electronic device. Thus, Regular monitoring, shuffling and mixing was performed using garden fork and trowel to promote effective decomposition. Along with this, temperature and internal moisture level was recorded to ensure and determine the compost maturity.

Fig 1: Bulk Compost method: Tea waste washing (a-b), Draining (c), Pot filling (d-e), Incubation (f-g) and Shuffling (h)

2. Domestic Subsequent Collection Method

This method can be used to prepare Tea waste compost using daily subsequent collection of Tea waste in a medium sized or 10 inch length earthen pot. It is convenient, time saving method, as well as does not require much efforts for the process. The compost usually gets ready to use in a one-month time.

In the present method; the daily generated domestic tea waste was collected, washed 2-3 times with tap water, allowed to drain in order to remove excess moisture in sieve and then transferred in to a medium sized clay pot. This way, day to day generated tea waste was collected in a pot following the same manner.

Fig 2: Subsequent Collection Method for making Tea leaf waste Compost: Washing (a), composting in a Clay Pot (b)

For the aeration purpose; the collected tea waste mixed thoroughly on an alternate day. The pot was kept at a shady, cool place and covered using a cardboard. As the washed tea waste contains 95 % of humidity; the compost making process does not require addition of water in this method. Also, due to less organic matter; temperature rise above 30°C is less observed. The earthen pot due to porous walls controls the temperature by providing moisture evaporation and cooling effect.

In addition, at the time of second batch of compost preparation; the small amount of earlier batch can be incorporated in to the fresh batch to fasten the decomposition process. Here the earlier batch material act as an inoculum of decomposer microorganisms to the newly prepared batch. This is an optimal process and serves as a value addition in the current process.

b. Soil: Compost (3:1) ratio Mixture Preparation

To test the benefits of adding compost in to soil; the Soil: Compost mixture (3:1) was prepared. Here three parts of Soil and one part of Compost was mixed. Weight was measured by digital Weighing Scale.

The experiment set was prepared by filling the Soil: Compost mixture. To prepare 1 kg quantity of above mixture; 750 gm of garden soil was uniformly mixed with the 250 gm quantity of Tea Waste Compost. The field experiment included testing the Plant Growth impact of normal Garden Soil and the Garden Soil mixed along with the Compost in a 3:1 ratio. The Physico-Chemical Property of the mixture was also tested compared to the normal soil.

c. Physico-chemical property of soil and soil: compost mixture

1. Water Holding Capacity

The Water Holding Capacity was measured for Soil and Soil: Compost mixture by Gravimetric method using standard method.

$$\text{Water Holding Capacity (\%)} = \frac{\text{Weight of water retained}}{\text{Oven dry weight of soil}} \times 100$$

or

$$\text{WHC (\%)} = \frac{W_2 - W_1}{W_1} \times 100$$

Where:

- W_1 = Oven-dry weight of soil (g)
- W_2 = Weight of saturated soil after drainage (g)

Determination of pH Value

The pH measurement of Soil and Soil: Compost mixture (3:1) filtrate was measured using Digital pH meter. To prepare Soil filtrate and Soil: Compost mixture (3:1) filtrate; 50 gm dry sample was mixed with 200 ml in a 250 ml conical flask and kept overnight. Next day the content was filtered using Whatman filter paper and used to test the pH.

Results and discussion

a. Compost preparation method and maturity duration

Various biological wastes such as Plant debris generated in garden, Agricultural residues and Kitchen waste etc. are often recycled as an eco-friendly practice by individuals.

The Indian tea waste generated usually contains residues of sugar and milk. Thus, it becomes essential to wash it two to three times with water to ensure the growth of beneficial microorganisms on the biological waste. The presence of sugar and milk particles promotes different types of microorganisms which creates fermentation and lipid or fat present within the milk promotes not so beneficial and different type of microbes and due to their biological activity, all these emits an awful, putrid smell from the decomposing material.

After washing the freshly collected tea waste; it does not possess any smell and shows a clear dark brown colour. After the excess of water draining process; its texture remains as light weight, granular, spongy and without any distinct smell. The fresh tea waste when filled in an earthen

pot; it allows the aeration; provides cooling effect by moisture evaporation from pot surface and suitable size for decomposition of 5 kg of tea waste. Earthen pot thus promotes the growth of aerobic microorganisms for fast and odour free decomposition.

The earthen pots covered using breathable cardboard again offers efficient growth of beneficial and aerobic type decomposer micro-organisms by allowing air circulation. The decomposition process includes slow digestion of organic matter by natural occurrence of fungus and bacteria.

At an initial stage of Decomposition process; first white mycelial growth of fungi appears and they occupy the waste surface rapidly. After 4 to 5 days the growth of aerobic bacteria increases and further decomposition happens by means of combined action of Fungi and Bacteria. Aerobic decomposition is a favourable process. The starting one-week time period includes slow growth of decomposer microorganisms and due to their digestion and growth on substratum; it raises the temperature of the organic matter in this case tea waste reaching up to 35°C. If temperature exposure to more than 30°C extends from longer duration; then it can inhibit the micro-organisms growth.

Thus, once the decomposer population establishes on the substratum; it increases the internal temperature by biological activity. If the high temperature sustains for the longer duration of time; then it may inhibit the growth of microbial population. Thus, this is negative effect usually seen during the decomposition process and temperature control under certain limit is required. As in the present study; earthen pots were used to prepare the Compost; it supports cooling effect by means of the porous breathable pot surface and moisture evaporation ability. Thus, in our study; the compost preparation process was scientifically appropriate.

The tea waste material during the decomposition process; loses some humidity and also shows decease in the filled mass or volume of the waste within the clay pot. Usually compost maturation takes 25- 30 days or one month time. But adding the earlier batch; small portion of matured compost as an inoculum; then the next batch takes a little shorter time to mature and compost gets ready within 25 days' time.

In the present study; both the Bulk method and Subsequent Collection method are suitable to utilise the tea waste and convert it in to a valuable compost product in the same time duration and had taken 25-30 days to completely ripen (Fig. 1, 2, 3). The composting process was initiated in the January month and Winter season. Thus, tea waste composting helps to recycle the green waste following simple steps and without causing any harm to environment by dumping them in a green waste bin.

In the present study; close monitoring of biological Waste Decomposition process by recording temperature changes and Compost maturity process is studied involving following major steps [6]. During the ongoing biological activity; according to the variable internal temperature parameters; Composting process involves following sequential 4 phase process along with their usual temperature range:

1. Mesophilic Phase (25-30°C),
2. Thermophilic Phase (30-40°C),
3. Cooling Phase (or 2nd Mesophilic Phase)
4. Maturation or Curing Phase (Cooler than atmospheric Temperature).

The whole process of decomposition includes four different phases where different temperature ranges indicate progression of one phase in to another like Thermophilic, Mesophilic; and Maturity Cooling Phase (Table 2). At a last Maturity Phase; the temperature drop is observed indicating that the decomposers have digested the organic matter completely and thus they cannot grow further. Each stage takes around one week time to enter in the next stage. The process requires growth of aerobic microorganisms and thus occasional mixing after 2-3 days are required and temperature control by appropriate ventilation need to be managed.

Table 2: Compost Maturity Stages as per time duration

Days	Atmospheric Temp (°C)	Compost Temp (°C)	Compost Maturity Stage
1	23.8	35	Mesophilic
3	24.3	32	
6	24.2	31	Thermophilic
9	25.2	29	
12	25.5	27	
15	25.7	26	Cooling
24	26.6	25	Curing

By means of using Bulk method or the Domestic Subsequent Collection method as per the availability of waste; both yielded same quality compost after 30 days' time period.

Tea leaf waste produced after brewing process contains just the cell wall structure and few tannins and phenol like secondary metabolites. Due to boiling process during the brewing; the tea leaves already got enough soften to be easily processed further by microorganisms during Decomposition. The tea leaf compost also owing to particulate and granular texture of the tea waste; the microorganisms can easily sustain on the surface with sufficient aeration. The enough surface area available for the disintegration and breakdown activity. In addition; the matured compost is again granular and can be easily mixed in the soil and created beneficial effects within the soil layer. Due to its porous texture; it reduces the compactness of the dense soil and promotes growth of healthy micro flora. It also reduces the population of disease-causing pathogenic microbes and reduces the chances of disease infestation on growing plants [2].

The fully mature compost is crumbly in texture, light weight and porous, dark black in colour and emits camphor like sweet odour indicating good quality compost. This type of decomposition results in to formation of Humus- a very fertile layer often formed on Soil surface near vegetation. After attaining the maturity phase and at 40% humidity; the compost was utilised to conduct field study to determine its effect on plant growth (Fig. 3).

b. Effect of Compost on Plant Growth

The compost material serves as a spongy, light weight, decomposed organic material like a humus; which not only works as a soil conditioner but also increases the water holding capacity of soil, supports the growth of soil microflora and helps in slow release of nutrients towards plant roots. The compost also provides major

macronutrients like NPK and thereby replenishes the nutrient depletion from soil.

The present work will be continued and the effect of addition of compost in soil and the plants grown on the Soil: Compost mixture will be studied to prove the beneficial aspects associated with this free of cost compost. Various plant growth parameters like plant height, number of nodes, leaves, fruiting, root growth, fresh and dry weight of plants.

Fig 3: Compost by Bulk Method at Maturity Stage and ready to use for gardening (a-c)

Physico-Chemical Property of Soil and Soil: Compost Mixture

The Water Holding Capacity observation by Gravimetric method had shown a better water retention by the Soil: Compost mixture compared with the soil. The Soil had shown 90 % and the Soil: Compost mixture (3:1) exhibited 105 % of Water Holding Capacity.

The pH value of the garden Soil was measured using Digital pH meter and exhibited pH 7, while the Soil: Compost (3:1) mixture exhibited 7.5 pH value. Thus, the absorption of minerals from soil by roots does not get much affected and the mixture can be beneficial for the overall plant growth.

Future Scope of Composting

The recycling the green waste helps in reduction in pollution and sustainable Development. The usage of chemical-based products such as fertilizers and pesticides can be reduced and also an eco-friendly practice can be promoted by using the domestic green waste as a nutrient rich fertilizer to their garden areas and to cultivate domestic need-based herbs and crops and ornamental plants.

The present study work was focused on to develop an easy to follow and convenient method to reduce the tea leaf waste going to the green bins and to effectively utilise it for the cultivating plants in the home surroundings and the small-scale nursery holders can also practice the tea waste to raise their nursery beds and saplings at a minimum expenditure.

The standardisation process was not worked out and the current work has served to fill this gap. Also, efforts are made to create awareness about reducing and recycling green waste to save environment and further experiments are also designed to check the effect of compost on plant growth. The work will be continued and the plant growth related findings will be recorded. The suitable proportion decided is the Soil: Compost mixture is in 3:1 ratio. As the compost is a rich source of NPK, it can harm root growth if used in a high amount.

Usually work on recycling of Kitchen waste, Agricultural waste is explored and in urban areas, few well aware people do practice the recycling of their kitchen waste and to convert it in to valuable compost also a Vermicomposting practice effectively works here. Kitchen waste includes the scraps, peels, vegetables cuttings, fruit and non- consumable ripen items except decayed products and dairy. They have a high sugar, minerals, organic nutrients and moisture content. Thus, during their composting; they release excess moisture and removing the liquid collected at the bottom of the composting bin is necessary. Shifting of heavy, large sized compost bin becomes difficult. Also, the wet waste emits a pleasant smell and supports the growth of maggots and attracts small insects. Complete decomposition takes about three months' time and regular mixing is required which needs efforts. Also, sieving process is required to separate decomposed small particles and large undecomposed pieces to be composed further. Thus, many people do not like performing the composting process. Instead, the tea waste has minimum organic nutrients, high surface area for the activity, simple to degrade due to absence of lipids and fat content, does not release excess water and does not emit unpleasant smell. Comparatively less care and management are required for the composting and have a better water holding capacity as compost. Lesser time required for complete composting, less maintenance, odourless process and convenient to use make the tea leaf waste an effective raw material to be process for making the compost.

Conclusion

The present work was carried out to study the Tea waste recycling process and to convert it in to a low-cost compost which can be easily used as soil conditioner organic matter for the Home Gardening, Kitchen Gardening and Nursery raising of plants to improvise the plant growth. The benefits of adding small quantity of compost in the soil growing mixture or adding as a mulching material can definitely provide multiple beneficial effects to the raising plants or saplings with no additional cost.

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