



## A Case Study on The Waste Generation and Routes of Disposal of Roadside Small Tea Stalls of Ramgarh Area

*Uma Kumari<sup>1</sup>, Taniya Sur<sup>2</sup>, Soumak Sadhu<sup>3</sup>, Shrubawati Sarkar<sup>4</sup> Sambit Tarafdar<sup>5\*</sup>*

<sup>1</sup> Department of Biotechnology, Radha Govind University, LalKiGhati, Ramgarh, Jharkhand

<sup>2</sup> School of Biotechnology Kalinga Institute of Industrial Technology University, Bhubaneswar, Orissa, India.

<sup>3</sup> Department of Biochemistry, University of Calcutta, West Bengal, India.

<sup>4</sup> Department of Zoology, Derozio Memorial College, West Bengal, India.

<sup>5</sup> Amity Institute of Virology and Immunology, Amity University, Noida, India.

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### Abstract:

Tea is a very common beverage that is consumed around the world. Consumption of tea has huge health benefits as it contains a wide spectrum of phytochemicals. Tea is consumed in various forms like black tea, green tea, jasmine tea, etc. India is considered a major producer and exporter of tea in the world. It has been reported in the literature that on average within every two kilometers in India you will find a tea stall. The tea in such stalls is mainly served in plastic cups, paper cups, and earthen cups. Moreover, a gigantic volume of spent tea leaves is generated as a result of the preparation of tea. In context to that, it may be corroborated that, a huge chunk of solid waste is being generated from such small tea shops which in turn has no practical applications. Such wastes also face serious issues related to their storage, management, and disposal. Accordingly, to put an insight into the volume of such tea waste generated; a small case study was conducted as a part of this project. We went to ten different small tea stalls of Ramgarh cantt and carried out a small survey to determine the various amount of waste generated by these shops on a daily basis. The results obtained from the survey were thought-provoking. It was noted that most of these solid wastes were practically not recycled and are simply dumped into various dump yards. Thus, the extended aim of the study was aimed toward the identification of various routes for the valorization of the various wastes generated from these tea stalls in the form of spent tea leaves and various types of containers used for serving the tea. The proposed scheme of work will definitely help in promoting environmental security and accordingly, will be beneficial to the various stakeholders.

**Keywords:** Tea; spend tea leaf, cups, valorization; environment, sustainability.

### 1. A Brief History of Tea

In 1689, Ovington records that tea was taken by the Baniyas in Surat without sugar, or mixed with a small number of conserved lemons, and that tea with some spices added was used against headache, gravel, and gripe. The tea leaves for such use may have come from China (Zhang et al. 2020). While experimenting to introduce tea in India, British colonists noticed that tea plants with thicker leaves also grew in Assam, and these, when planted in India, responded very well (Karlsson 2022). The same plants had long been cultivated by the Singphos tribe of Assam, and chests of tea were supplied by the tribal ruler Ningroola. The Assamese and Chinese varieties have been regarded in the past as different related species, but are now usually classified by botanists as the same species, *Camellia sinensis*. In the early 1820s, the British East India Company began large-scale production of tea in Assam, India, of a tea variety traditionally brewed by the Singpho people. In 1826, the British East India Company took over the region from the Ahom kings through the Yandaboo Treaty (Gogoi 2021). In 1837, the first English tea garden was established at Chabua in Upper Assam; in 1840, the Assam Tea Company began the commercial production of tea in the region. Beginning in the 1850s, the tea industry rapidly expanded, consuming vast tracts of land for tea plantations. By the turn of the century, Assam became the leading tea-producing region in the world. The introduction of Chinese tea plants, different from Indian tea, to India is commonly credited to Robert Fortune, who spent about two and a half years, from 1848 to 1851, in China working on behalf of the Royal Horticultural Society of London. Fortune employed many different means to steal tea plants and seedlings, which were regarded as the property of the Chinese empire (Soni et al. 2015). He also used Nathaniel Bagshaw Ward's portable Wardian cases to sustain the plants. Using these small greenhouses, Fortune introduced 20,000 tea plants and seedlings to the Darjeeling region of India, on steep slopes in the foothills of the Himalayas, with the acid soil liked by *Camellia* plants. He also brought a group of trained Chinese tea workers who would facilitate the production of tea leaves. With the exception of a few plants which survived in established Indian gardens, most of the Chinese tea plants Fortune introduced to India perished. The technology and knowledge that was brought over from China were instrumental in the later flourishing of the Indian tea industry using Chinese varieties, especially Darjeeling tea, which continues to use Chinese strains (Cunliffe 2014). From the first, Indian-grown tea proved extremely popular in Britain, both for its greater strength and as a patriotic product of the empire. Tea had been a high-status drink when first introduced, but had steadily fallen in price and increased in popularity among the working class. The Temperance movement massively promoted tea drinking, from the early 19<sup>th</sup> Century, as an alternative to beer – water being of dubious quality, but the complete boiling necessary for tea rendered it safe. Many men in particular found China tea insipid, and the greater strength and lower price of Indian teas appealed greatly. By the last

quarter of the nineteenth century, big brands such as Lyons, Liptons, and Mazawattee dominated the market (Masquelier 2013). Tea was the dominant drink for all classes during the Victorian era, and working-class families often doing without other foods in order to afford it. This meant the potential market for Indian teas was vast. Indian tea (effectively including Ceylon tea from Sri Lanka) soon came to be the "norm", with China tea a minority taste. Until the 1970s and the rise of instant coffee, Indian tea had almost sole command of the hot drinks market. Its rivals were cocoa, coffee, and savory drinks such as Bovril and Oxo. In recent decades Asian tea has lost much ground in the cheaper end of European markets to tea from Africa, especially Kenyan tea (Bond 2011).

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## 2. Introduction:

*Camellia sinensis* - Tea Plant Responsible for Types of Teas. All types of tea come from the *Camellia sinensis* plant, an evergreen shrub that may grow up to sixty feet in the wild. When cultivated for harvest, tea bushes are kept to a height of about three feet (Das et al 2012).

There are over 3000 varieties of tea, each with its own specific characteristics. The naming and growing of teas are in many ways similar to wine. Just as Bordeaux wine is named after the Bordeaux region in France and Champagne can only be produced in the province of Champagne, many teas are also named after the area they are grown in. For example, Assam tea is named after the Assam region in India and Yunnan tea is named after the Chinese province. Like wine, where the tea is grown, the climate, soil conditions, and how the tea is processed will altogether determine its flavor characteristics (Pan et al. 2022).

While there are literally thousands of teas in the world, as a subject of classification tea can be broken down into the following major types:

- **Black Tea-** Black tea is withered, fully oxidized, and dried. Black tea commonly yields a hearty, amber-colored brew. Some of the most popular types of black teas are bold breakfast teas (e.g., English Breakfast, Irish Breakfast) and Darjeelings (Martin 2011).
- **Green Tea-** Green tea production endeavors to avoid the oxidation of the tea leaves, in order to retain its natural green color and fresh flavor. In Japan, the leaves are steamed, while in other countries will pan-fire or dry it through other methods. This type of tea has a more delicate flavor than black tea and often brews up pale green or golden in color (Vuong et al. 2011).
- **Oolong Tea-** Oolong tea is produced mainly in China and Taiwan and is only partially oxidized. This type of tea can range from tasting similar to a fresh green tea, The flavor can vary widely, depending on where the tea leaves are grown and how the tea is made (Chen et al. 2010).
- **White Tea-** Originally from China, white tea is simply withered and dried, causing very light oxidation. Its flavor is most similar to that of green tea but is usually more creamy, soft, and sweet (Sajilata et al. 2008).
- **Pu-erh-** Pu-erh (also spelled pu'er) comes exclusively from China and is famous for its distinctively earthy flavor. Pu-erh is a tea that has been fermented, often stored underground for several years. Traditionally, pu-erh is compressed into round cakes and can be very expensive (Mobegi et al. 2012).
- **Yellow Tea-** Yellow tea is the rarest type of tea. It is similarly processed to green tea but is more slowly dried to make the leaves take on a yellow color. The taste of the tea is mild, often described as being somewhere between white and green tea (Hazra et al. 2019).
- **Herbal Infusions & Herbal Tea-** Tea is not to be confused with herbal infusions. While herbal tea or infusions are packaged like tea, infused like tea, and enjoyed like tea, they actually do not contain any tea leaves. Herbal tea is simply the combination of boiling water and botanicals like fruits, flowers, bark, herbs, mints, spices, roots, berries, and seeds (Gill 1992).

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## 3. Market Analysis

The tea industry in India is being driven by the high penetration of the beverage in the country across socio-economic classes. India's healthy economic growth and the subsequent rise in the middle-class population are also proving to be catalysts for the industry's growth as consumers are preferring premium brands. The rising demand for the packaged variety of the beverage in both urban and rural areas due to lesser chances of adulteration, convenient storage, and superior quality is further aiding the tea industry in India (Van Der Wal 2008). The demand for packaged varieties with natural ingredients is also witnessing growth. The middle class is also willing to experiment more with tea blends, thus, providing an impetus for the growth of segments like fruit, herbal, and other specialty varieties. Green tea is expected to witness robust growth in the coming years as its consumption is witnessing an increase as people become more aware of its health benefits. The industry for green tea is being driven by the urban population, supported by the increased intake of beverages without milk in these areas. Thus, the rapid urbanization along with the rise in disposable incomes in the country is further aiding the tea industry in India. The growing popularity of cafes/lounges primarily serving variations of the beverage is expected to drive the industry in the coming years. The convenience of its distribution channels like local 'kirana' stores and supermarkets, along with the growing online channel, will also aid the industry growth. With busier lifestyles and a growing workforce, the RTD segment has the potential to witness a healthy increase as consumers seek more convenient foods and beverages. The industry will also be driven by the increasing innovation in packaging and flavors in the coming years. The rural sector presents another segment for the expansion of the industry (Crozier et al. 2011).

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#### 4. Key Industry Players in the Tea Market in India

The report gives a detailed analysis of the following key players in the tea market in India, covering their competitive landscape, capacity, and latest developments like mergers, acquisitions, investments, expansions of capacity, and plant turnarounds:

- Tata Global Beverages Limited
- Hindustan Unilever Limited
- Gujarat Tea Processors & Packers Ltd
- Amar Tea Private Limited
- Organic India Private Limited
- Pataka Industries Private Limited
- Others

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#### 5. Tea Consumption Pattern

Tea is by and large a highly penetrated product. A layered approach has been adopted to arrive at the overall penetration levels for tea as a category. The penetration of tea in the kid segment below 12 years of age which on average comprise ~25% of the overall population is almost negligible. In the next layer, we estimate the penetration of tea in households. Close to 88% of the total households (based on the samples in the survey) in India have reported consumption of tea. Among the potential tea drinkers within a household, the penetration of tea is around 96%. Overall, around 64% of the total population in India is a tea-drinking population (Chen et al. 2015). Across Socioeconomic classes, there is hardly any significant difference, since tea is a traditional drink and is considered one of the most affordable beverages.

There is a marked difference in the proportion of in-home and out-of-home consumption. This is driven by a number of factors primarily led by urbanization. Western and Southern States show a higher proportion of out-of-home consumption compared to the North, Central, and East. Quality concerns and the stigma attached to having food outside the home (especially in the North) may be some of the key reasons. Most of these out-of-home consumption occurs in workplace canteens. This also supports the fact that higher out-of-home consumption occurs in those regions where urbanization/industrialization has taken place and there are increased commercial activities. Over 80% of people consume tea either before breakfast or with breakfast, which is also one of the reasons behind the high in-home consumption of tea. A certain proportion also considers tea as an “any time of the day” drink. This segment is sizeable in the Eastern parts of the country. Milk tea with sugar is the most popular choice with more than 80% of the households preferring the same. In recent times, however, the consumption of non-milk tea without sugar is on the rise, driven majorly by the increasing emergence of lifestyle-related diseases and the increasing popularity of variants such as green tea. Among milk tea drinkers, the addition of ginger is one of the key trends that has been highlighted, while among non-milk tea drinkers, green tea and lemon tea are fast becoming the popular choice after plain liquor tea. There are some region-specific characteristics in tea drinking; the proportion of respondents preferring milk tea is higher in the Northern and Western states (the overall consumption of milk is also very high in the states) compared to the other parts of the country. Biscuits are the popular choice of accompaniments while having tea at home, while a large percentage of respondents prefer to have nothing at all while having tea outside the home. The western states however have a significant proportion of households preferring salted snacks with tea which can be attributed to the growing purchasing power in the region. Studies also revealed that the Consumption of tea varies to some extent with seasonality. Tea consumption as per the study increases during winters and festive occasions across the country by and large (Jaeger et al. 2011).

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#### 6. Tea Purchase Behaviour

Close to 80% of households (in Urban India) and around ~ 75% of households (in Rural India) have shifted to buying packet tea. Packet tea means tea not sold in loose forms. This segment broadly includes tea from National brands, established regional brands, and also the local players who have forayed into packaging and selling under their own labels. The driving force behind the transition can be linked to consumers preferring to packet tea because of its perceived quality (adulteration-free) and better storage options. The proportion of loose tea is comparatively higher in the Eastern and Central States compared to the rest of the country. Favorable demographic factors such as an increase in disposable income, aspiration levels, more participation in the workforce (both male and female), and increasing health consciousness have by and large contributed to the shift from loose tea to the packet. With increasing demand, there has also been a marked improvement in rural penetration and a significant number of wholesalers are diversifying from low margin high volume wholesaling to high-margin retail business. Neighborhood kirana stores are the most common place for tea purchases, with more than 70% of the households surveyed buying tea from these stores (Astill et al. 2001). Convenience and proximity play a major role in deciding the place of purchase. However, most retailers have shifted to a cash-and-carry model, where no purchase is done in credit, especially in the urban segment. Modern retail is emerging as the second biggest channel for purchasing tea. With an increasing shift of preference of consumers from loose to packet tea, and penetration of modern retail increasing in India (with the rising number of Tier 2 and Tier 3 cities contributing significantly to the supermarket space), this channel may become a major source of purchasing packet tea. With convenience emerging as a major factor in consumer buying behavior, and the increasing availability of smartphones, online channels will be a major driver for the increasing shift towards the consumption of packet tea. This will be driven by increased internet penetration and digital connectivity even in rural India. About 7% of the household purchase tea from the exclusive loose tea shop. The loose tea market is divided into two distinct segments – one segment is very price

sensitive and buys cheap inferior quality loose tea while the other segment is quite aware of the quality of loose tea and buys good quality loose tea which suits the taste and preferences of their households (at a cost lower than the branded packaged tea). There are region-specific differences in preferred attributes of tea. While overall, the taste and strength of liquor are important factors, in rural India. Some parts of Rural India in select states, especially the South, prefer the dark color of tea and associate it with better quality of tea. This has led to the proliferation of some packet tea players who are using coloring agents to enhance the color of tea. Around 21% of households reported they have switched brands over the last five years. The major reasons behind the brand switch were the poor taste and quality of tea from the previous brands. With a very low entry barrier and the increasing number of regional brands coming up regularly across India, this switching behavior is expected to increase further. Tea is by and large a price-inelastic product. It is looked upon as the common man's drink which is consumed on a daily basis rather than being perceived as an aspirational drink. The survey tried to understand the change in buying behaviour in case there is a change in price points. A very minuscule percentage responded that they will stop consuming tea in case of a price increase which clearly testifies to the fact that tea is a drink that is perceived to be of daily necessity and hence relative price inelasticity. Wallet share analysis reveals that on average, around 22% of the overall households spend more than INR 200 monthly for tea. This percentage varies across regions. While the percentage is relatively higher in the West and South, indicating higher awareness and hence higher spending, the percentages are lower in the North and East, even though significant consumption happens in North India. A large number of households who do not spend a significant amount on tea consumption can be made aware of the benefits of quality tea and different high-end variants of tea, which might enable them to spend a greater percentage of their F&B budget on tea. Availability issues have reduced as the rural penetration of most of these tea companies has increased over the years. However, some households have reported availability issues with high-end varieties like green, flavoured, and Earl Grey tea (Talbot 2002).

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## **7. Awareness, Perception, and Emerging Trends**

Assam Tea and Darjeeling Tea are the most recognized tea by place of origin. Awareness about the origin of tea is correlated with the proximity of the states to the producing region. As a result, awareness about Darjeeling tea is high in the East while awareness about Nilgiri tea is high in the South. Awareness levels of Assam tea are highest across India followed by Darjeeling tea. The major source of awareness about tea is generated retailers (who play a significant role in generating awareness and influencing tea purchases) and cable/satellite TVs. Word-of-mouth publicity (Colleagues/ friends and relatives) also plays a major role, especially in Northern and Southern states. Most people are aware of tea in general which is testified by the high penetration levels among households while awareness levels about green tea are slowly making steady inroads. Awareness about these is significantly high in the Southern states. Green tea is fast becoming a popular drink across ages due to its perceived health benefits and is fast becoming one of the popular products in the health and wellness segment. The awareness levels are especially high in metro cities or in regions where non-milk tea consumption is more than the national average (Gupta et al. 2022). Among the beverages, tea, and coffee are considered the beverages which are most convenient to prepare. With an increasing number of families having working couples or individuals staying away from their families, the convenience of preparation is an important aspect. Keeping this in mind, there is a potential for Ready to drink tea (RTD) which needs to be properly tapped. RTD tea is expected to grow about 5% over the next 4-5 years, which is higher than the expected growth rate of normal tea. Tea can be positioned as a refreshing drink that can be afforded by the common man. However, the easy affordability of tea has often led to its commoditization. As a result, a significant proportion of households across India consider coffee as a symbol of social status and offered it to important guests. A significant proportion of households consider that tea is associated with ill health such as loss of appetite, and increased acidity. However, people need to be properly made aware of the different aspects of preparing tea, storing it, and the health benefits associated with drinking quality tea which can potentially change the negative perceptions about tea. Awareness about quality is significantly low in the country with close to 90% of the respondents across India associating the quality of tea with brands. Awareness of Geographic Indication marks is more in the West and North, the traditionally high tea-consuming belts of India. However, awareness of certifications is not high as revealed by the survey and awareness is low even in the educated sections. But, with an increasing shift towards packet tea and price (for quality tea) sensitivity being low among consumers, quality certifications at a moderately higher price and guaranteed quality can be an effective way of inducing a safe tea-drinking culture (Shil et al. 2012).

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## **8. Case Study**

### ***Prelude:***

It was noted from the earlier section, that a huge tea consumption takes place in India, which in turn produces a huge number of wastes like waste tea leaves, and waste tea cups (both plastic and earthen cups). Therefore, an ardent need was identified for the proper disposal management plan for tea waste (Roy and Ray 2019; Roy and Ray 2020). To have a real insight regarding the number of wastes generated from tea, a survey was conducted on different small tea stalls across ten various locations of Ramgarh Cantt, Jharkhand. Initially, we went to the various small tea stall owners and asked them a few questions which have been presented below. Overall, we conducted 10 field surveys and tried to figure out how much tea waste is produced in various forms. In order to ensure individual privacy, we have not revealed the name and photograph of the owner of the tea shop. The survey would put a brief insight, regarding how much tea waste is generated daily, and finally, we will put some mitigative measures in order to valorize the same.

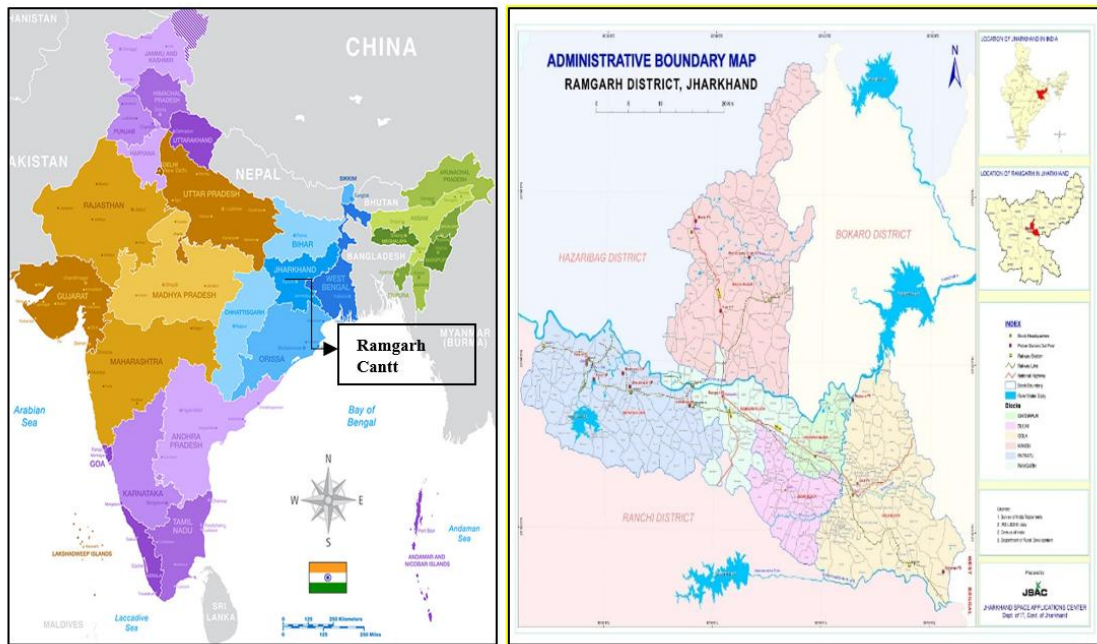
### ***Aims and objective of the study:***

Tea is a very popular beverage in India. The literature indicated that a huge quantity of tea waste is generated which faces serious issues related to their storage, management, and disposal (Roy, Debnath, and Ray 2022; Roy and Ray 2022). After an exhaustive literature search, it was identified that spent tea leaves have great potential in various pathways like microbial-assisted wastewater remediation, energy generation, etc. (Ghoshal et al. 2022; Roy et al. 2022). Accordingly, an obvious research scope was identified for the estimation of the tea waste generated from various tea stalls in a small locality

of Ramgarh Cantt. Initially, the study aimed to identification of the tea consumption pattern and the analysis of the tea market. Furthermore, the study investigated the various pathways related to the valorization of the spent tea leaves. The final aim of the study was to perform a case study to estimate the various amount of waste generated from small tea stalls in Ramgarh Cantt.

### **Methodology Adopted in the Study**

The case study conducted in this thesis was to determine the number of various types of waste generated from the small tea stalls of Ramgarh Cantt. Initially, a location was selected in the Ramgarh Cantt. The location has been indicated in Figure 1. An exhaustive set of questions was framed to identify and estimate the various kinds of waste generated from the tea stalls of Ramgarh Cantt. We selected ten tea stalls and interviewed the shop owners. We tried to cover a broad region and selected a single tea shop from a locality. Such initiative was taken to ensure natural distribution. Along with the types of waste generated by the shops, various other questions were also asked the shopkeepers to have a brief insight regarding the selling pattern of the shops.



**Figure 1** Geographic location of the survey area.

### **Fieldwork:**

We conducted elaborate fieldwork to substantiate the number of tea wastes generated from amount of various tea waste generated from small tea shops across various tea stalls in Ramgarh Cantt. We framed a set of questionnaires and accordingly, interviewed various small tea shop owners. The results of the following survey have been indicated below.

#### **Survey 1:**

<b>Questions</b>	<b>Answer</b>
Location of the tea stall. How many people are working?	Bijulia, (Near Railway Station). Pin code: 829122. One owner and one helper.
For how many years, the tea stall has been running?	More than 15 years.
What is the fuel used for preparing tea?	Coal.
What is the operation time of the tea stall?	Morning 6 AM to Night 10 PM.
Approximately how many cups of tea are sold daily?	1200-1400 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea, ginger tea.
What types of cups are used to serve tea?	Paper cups, plastic cups.
How much waste tea leaves are generated per day approximately?	2 -3 kg of tea waste is generated daily.
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

#### **Survey 2:**

Questions	Answer
Location of the tea stall. How many people are working?	Thana Chowk, Ramgarh Pin code: 829122. One owner and two helpers.
For how many years, the tea stall has been running?	More than 18 years.
What is the fuel used for preparing tea?	Coal & LPG Gas Cylinder
What is the operation time of the tea stall?	Morning 5 AM to Night 11 PM.
Approximately how many cups of tea are sold daily?	1500-1800 cups per day are being sold daily
What types of tea are being sold?	Milk tea, black tea
What types of cups are used to serve tea?	Paper cups, earthen cups.
How much waste tea leaves are generated per day approximately?	4-5 kg of tea waste is generated daily.
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 3:**

Questions	Answer
Location of the tea stall. How many people are working?	Chatti Bazar, Ramgarh. Pin code: 829122. One owner and two helpers.
For how many years, the tea stall has been running?	More than 10 years.
What is the fuel used for preparing tea?	LPG gas cylinder.
What is the operation time of the tea stall?	Morning 7 AM to Night 11 PM.
Approximately how many cups of tea are sold daily?	1400-1600 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea, ginger tea.
What types of cups are used to serve tea?	Paper cups, earthen cups, plastic cups.
How much waste tea leaves are generated per day approximately?	4.5-5 kg of tea waste is generated daily.
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 4:**

Questions	Answer
Location of the tea stall. How many people are working?	Ramgarh Bus Stand. Pin code: 829122. One owner and three helpers.
For how many years, the tea stall has been running?	20 years.
What is the fuel used for preparing tea?	LPG gas cylinder.
What is the operation time of the tea stall?	Morning 5 AM to Night 11 PM.
Approximately how many cups of tea are sold daily?	2500-2800 cups per day are being sold daily
What types of tea are being sold?	Milk tea, black tea, ginger tea, and tea without sugar.
What types of cups are used to serve tea?	Earthen cups, plastic cups.
How much waste tea leaves are generated per day approximately?	5-6 kg of tea waste are generated daily
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 5:**

Questions	Answer
Location of the tea stall. How many people are working?	Tyre More. Pin code: 829122. One owner and one helper.
For how many years, the tea stall has been running?	8-9 years.
What is the fuel used for preparing tea?	LPG gas cylinder.
What is the operation time of the tea stall?	Morning 7 AM to Night 9 PM.
Approximately how many cups of tea are sold daily?	800-900 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea, ginger tea, green tea.
What types of cups are used to serve tea?	Paper cups, plastic cups.
How much waste tea leaves are generated per day approximately?	2-3 kg of tea waste is generated daily.

Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 6:**

Questions	Answer
Location of the tea stall. How many people are working?	College gate (Near Ramgarh College). Pin code: 829122. One owner and two helpers.
For how many years, the tea stall has been running?	20 years.
What is the fuel used for preparing tea?	LPG gas cylinder.
What is the operation time of the tea stall?	Morning 6 AM to Night 9 PM.
Approximately how many cups of tea are sold daily?	1500-1700 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea.
What types of cups are used to serve tea?	Earthen cups.
How much waste tea leaves are generated per day approximately?	4-4.5 kg of tea waste is generated daily.
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 7:**

Questions	Answer
Location of the tea stall. How many people are working?	Subhash Chowk (Near Cantonment office). Pin code: 829122. One owner and one helper.
For how many years, the tea stall has been running?	14 years.
What is the fuel used for preparing tea?	Coal.
What is the operation time of the tea stall?	Morning 7 AM to Night 9 PM.
Approximately how many cups of tea are sold daily?	500-700 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea, ginger tea, and tea without sugar.
What types of cups are used to serve tea?	Plastic cups.
How much waste tea leaves are generated per day approximately?	1.5-2 kg of tea waste is generated daily
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 8:**

Questions	Answer
Location of the tea stall. How many people are working?	Block, Ramgarh. Pin code: 829122. One owner and one helper.
For how many years, the tea stall has been running?	5-6 years.
What is the fuel used for preparing tea?	LPG gas cylinder.
What is the operation time of the tea stall?	Morning 8 AM to Night 8 PM.
Approximately how many cups of tea are sold daily?	400-500 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea.
What types of cups are used to serve tea?	Paper cups.
How much waste tea leaves are generated per day approximately?	1-1.5 kg of tea waste is generated daily.
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

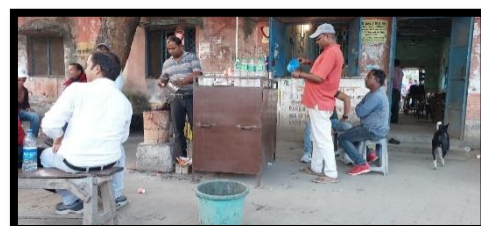
**Survey 9:**

Questions	Answer
Location of the tea stall. How many people are working?	Sanichar Bazar. Pin code: 829122. One owner and two helpers.
For how many years, the tea stall has been running?	10 years.
What is the fuel used for preparing tea?	LPG gas cylinder.

What is the operation time of the tea stall?	Morning 6 AM to Night 10 PM.
Approximately how many cups of tea are sold daily?	1200-1500 cups per day are being sold daily.
What types of tea are being sold?	Milk tea, black tea, ginger tea.
What types of cups are used to serve tea?	Paper cups, plastic cups.
How much waste tea leaves are generated per day approximately?	2.5-3.5 kg of tea waste are generated daily
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.

**Survey 10:**

Questions	Answer
Location of the tea stall. How many people are working?	Lohar Tola. Pin code: 829122. Two owners and two helpers.
For how many years, the tea stall has been running?	More than 15 years.
What is the fuel used for preparing tea?	Coal.
What is the operation time of the tea stall?	Morning 5 AM to Night 11 PM.
Approximately how many cups of tea are sold daily?	2000-2500 cups per day are being sold daily.
What types of tea are being sold?	Milk tea.
What types of cups are used to serve tea?	Earthen cups.
How much waste tea leaves are generated per day approximately?	4-5 kg of tea waste is generated daily.
Do they recycle any portion of the waste generated?	No, they collect all the waste in a dustbin and do not recycle.
What do they do with the tea cups and the waste tea leaf?	They collect all the waste in a dustbin and at the end of the day, they throw the waste into the local dumping yard.





**Figure 2** Few glimpses of the survey from various small tea stalls of Ramgarh.

**Results and Discussion:**

After the exhaustive survey of various small tea stalls, it was observed that a lot of waste is generated from the stalls in terms of paper cups, plastic cups, earthen cups, and spent tea leaves. All these wastes have no practical application and face serious troubles related to their storage, management, and disposal. Accordingly, various routes for their mitigation need to be adopted to promote and uphold their proper recycling to achieve overall sustainability. Accordingly, in the upcoming section, we have proposed various mitigative measures which will in turn help minimize the generation of such volumes of generated waste. These mitigative measures will definitely help in the promotion of overall environmental sustainability and will be beneficial to various stakeholders (Roy et al. 2022; Vipparla et al. 2022).

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## 9. Approaches for Improving the Recycling of Various Tea Waste

By definition, tea “waste” has little, if any, economic value. It’s a throwaway: dust, bits, and pieces of twigs, damaged fragments of leaf, floor sweepings, stalks, and leftover detritus that doesn’t meet the standards or processes that result in it becoming part of the packaged end product (Roy et al. 2022).

The term is misleading. Tea waste has many properties that can be turned into a commercial asset. Waste isn’t necessarily inert. The innovations exploit the chemical and molecular richness of the tea bush and its leaf. Waste retains polyphenols, antioxidants, catechins, flavanols, cellulose, amino acid, non-soluble proteins, caffeine, fiber, sugars, lignin, zinc, and tannic acid that make tea so rich in flavors, textures, and nutrients. The waste is easily processed to extract, mix, and shape these to create value instead of burning or burying it.



**Figure 3** Deposition of tea waster in different places of tea factories: (A) Inside factory shade (B) waste warehouse (C) processing center.

- Nutrients

The caffeine nutrient in the waste has a broad market with substantial export potential. It is extracted for use in many products, including cosmetics, fertilizers, instant teas, medical, and nutritional supplements. Tea waste makes a high-protein cattle feed after the removal of the tannic acid that interferes with protein metabolization. This can be done cheaply. The high fiber count makes it suitable for ruminants. It tastes pretty awful but is improved by adding molasses.

Caffeine is also the base for poultry and pig feed. Some Japanese specialty farmers market their pork as green tea fed. In Korea and China, tea waste is a not-infrequent part of pigs' diets. The distinctive contribution of tea is that its fat-soluble nutrients are not flushed out of the body but retained so that they affect flavor-building. A 2014 study of waste-fed young goats reported that it produced higher-quality meat, with lower "coarse" fat.

Another report points to waste being a superior ingredient for manufacturing supplements, with black tea waste matching cultivated green leaf in meeting quality and functional requirements, at a far lower price (Su et al. 2022).

- Adsorption

Adsorption is one of the growing areas of opportunity for tea waste. It is the collecting of molecules by a substance that retains them on its surface. They don't enter its interior (that is absorption). The difference is like spilling ice cream on your wrist (adsorption: it stays there and can be wiped off and your skin is unaffected) versus eating it (it's absorbed in your stomach and can't be recovered or reconstituted.)

The need for adsorption reflects the widespread environmental damage caused by the waste created in manufacturing across the globe. It's the base for removing stuff that runs off into fields and waterways, accumulates in the soil, and is non-degradable (Song et al. 2022).

- Here are a few examples.

Mixed with clay, tea waste forms adsorptive membranes for removing toxic effluents from ponds that are generated as a factory byproduct.

Black tea waste powder is an effective dye adsorbent. Dyes are a core ingredient in textiles, printing, papermaking, and cosmetics. The 2% that are directly fed into water resources are concentrated, have health hazards, and are seriously toxic. Try oolong waste: one study recorded a 98% efficiency in removing methylene blue dye by using it. By and large, waste made in processing any type of tea will do the job. It will match more complex and expensive techniques, such as catalytic oxidation and membrane separation.

Activated tea waste charcoal adsorbs lead, antibiotics, and heavy metals such as zinc, at a lower cost. This is a form of carbon processed to increase the surface area available for the adsorption of other compounds or stimulation of chemical reactions. This micro-porosity can make a single gram of carbon provide 30,000 square feet of the surface.

Activated carbon has largely been made from charcoal. This is complex and relatively expensive to produce. Biomass tea waste is growing as an effective substitute. Lightly treated with sulfuric acid it offers a widely available and highly environmental-friendly resource. It also has added properties that enable broader water purification, through advanced technologies like nanoparticles and capacitive deionization.

- Fertilizer

Tea waste is packed with the compounds that make for a superior fertilizer: nitrogen, potassium, and phosphorus. Case reports include horse stable manure when mixed with quarry sandstone dust, the substrate for mushroom growing, vermicomposting — worm activation — compost for foliar (direct leaf) spraying and soil drenching that improve the plant's access to nutrients and speed up toxin degradation, and specialty fertilizers with high levels of a particular ingredient, such as methane, ash, or potassium.

Finlay, the massive and now bankrupt Indian tea garden firm operates a biogas plant that takes black and green tea spent leaf as input from its farms and discharges it into a slurry lagoon to be used as a soil fertilizer for timber locations, new field clearing, and tea plantations. The digester can hold 7,000 metric tons of organic tea waste.

- Energy

Tea dust and stalks and all the other little bits of waste can be easily processed and turned into liquids and bricks as biomass fuel, bio-char, and bio-oil. The waste is decomposed using fluidized bed pyrolysis, a thermal decomposition process that occurs in the absence of oxygen. Tea waste pyrolysis at high temperatures of 500-700°C and through gasification produces bio-oil and biochar. The char can be converted into briquettes or mixed with biomass. This provides a highly efficient solid fuel for use in ovens and boilers across many industries – including tea. The techniques can be fine-tuned to optimize the yield of char, liquid, and gas (Roy and Ray 2019).

The cellulose in tea waste is the same as that of timber. The high levels of this plus sugar, starch, and pectin are encouraging the use of fuel briquettes to replace wood fuel for ovens. The waste is even able to generate battery-power electric charges via vermicomposting.

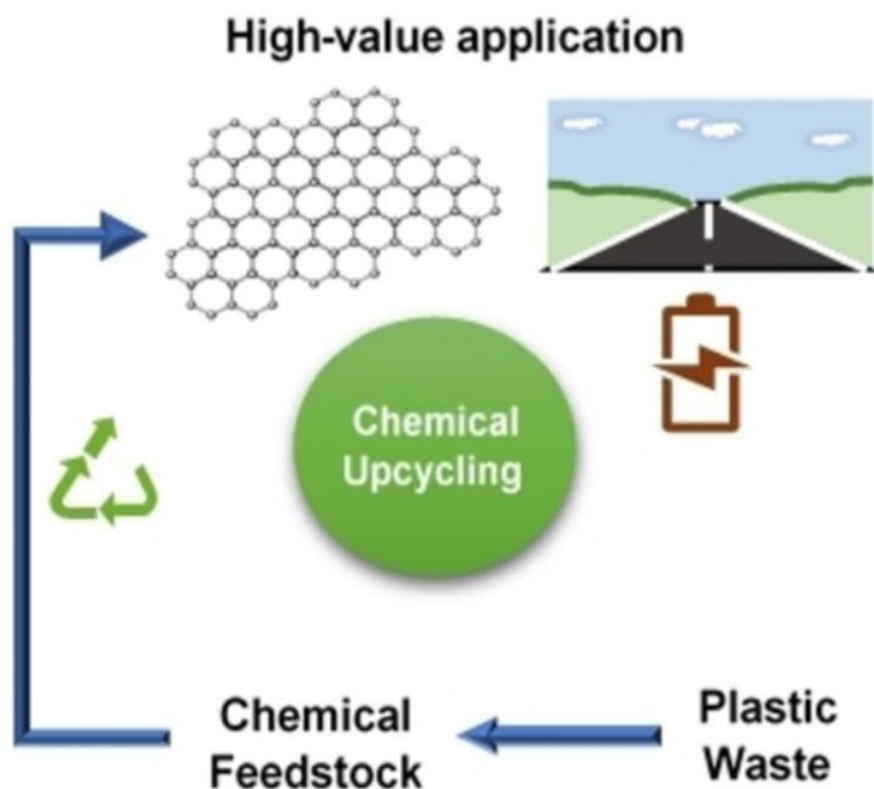
The use of tea waste to make fuel for tea making illustrates the circular economy, a framework for reducing waste through recycling, packaging, safety procedures, process, and product innovation to end the linear sequence in production and consumption of take-make-dispose.

Energy management is a major immediate target of opportunity for the circular economy. Electricity and fossil fuels comprise a large proportion of operating costs. There are many examples of crop waste being turned into biofuel. In Kenya, one small organization collects sugarcane waste from outside a factory where it has piled up for decades, dries and mills it before pressure compacting it into briquettes. These are smokeless and generate 50% more energy than equivalent sizes of logs (Roy and Ray 2022).

Mokomboki Tea Factory in Kenya initiated a program that shows the scale of direct energy savings by replacing firewood with briquettes made of biomass waste. Its energy expenses fell from \$542,000 to \$295,000. It has entirely eliminated the use of timber.

### ***Recycling of Used Cups from Various Tea Stalls***

Various types of cups (like plastic, paper, and earthen) generated from tea stalls are one of the major sources of pollution in landfills and oceans, this has raised global concern, primarily due to the huge production rate, high durability, and the lack of utilization of the available waste management techniques. Recycling methods are preferable to reduce the impact of plastic pollution to some extent. However, most of the recycling techniques are associated with different drawbacks, with high costs and downgrading of product quality being among the notable ones. The sustainable option here is to upcycle the plastic waste to create high-value materials to compensate for the cost of production. Several upcycling techniques are constantly being investigated and explored, which is currently the only economical option to resolve the plastic waste issue (Dey et al. 2022). This Review provides a comprehensive insight into the promising chemical routes available for upcycling the most widely used plastic and mixed plastic wastes. The challenges inherent to these processes, the recent advances, and the significant role of the science and research community in resolving these issues are further emphasized (Roy et al. 2022).



**Figure 4** Schematic representation of utilization of various waste cups generated from tea stalls.

### ***Different Proposed Pathways for the Valorization of the Spent Cups Arising from Different Tea Stalls***

Considering the harmful effect of paper, earthen and plastic cup waste around the world, it is extremely important to discard such waste thoughtfully, and many scientific communities dedicate special attention to waste management to save the planet from such pollution. Several techniques are adopted by different countries for waste disposal or management. One of the most common ways of waste utilization is landfilling. Recycling is another conventional and preferred way for plastic waste utilization. This section briefly describes the conventional ways of waste management and the associated challenges to put a perspective in place on the necessity of valorization of these types of wastes (Roy, Debnath, and Ray 2022).

### **Landfilling**

Landfilling was one of the most common ways of waste management till the year 2015. However, the well-known adverse effects of waste on the environment limit the adaptation of this basic technique of waste disposal. The non-biodegradable plastic waste and the harmful contaminants cause soil, air, and water pollution, which is a serious concern from an ecological point of view. Another problematic aspect is the accessibility of land for this type of waste disposal, considering the overgrowing usage of single-use plastics and their inconsiderate dumping. In addition, retrieval of any components is not possible by this technique and thus circular economy cannot be achieved. However, a relatively new approach has been initiated in many countries to close the loop of the circular economy by recovering plastic waste from landfill, also known as landfill mining, and recycling them by utilizing the currently available techniques. Nonetheless, this process has its own challenges due to the added possible contamination in landfills (Roy et al. 2022).

### **Reuse and Recycle**

In today's scenario, many countries are considering alternate ways of waste management, such as reuse, recycling, or energy recovery. Reuse and recycling are vital processes in reducing the long-term impact of plastic, paper, and earthen cup waste disposal. Reusing is preferred over recycling, as it lowers waste generation, eliminates the conversion cost associated with recycling, and minimizes the chances of harmful emissions in the environment. However, food packaging or single-use plastics are mostly thrown away, and recycling is necessary to avoid disposal in landfills. Several recycling methods are being used in different stages to convert these wastes into different products (Vipparla et al. 2022)

### **Chemical upcycling approach**

Valorization of plastic cup waste refers to the conversion of the waste material into value-added products. There are different types of plastics, such as polyolefins (e.g., polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC)), polyesters (e.g., polyethylene terephthalate (PET), polylactic acid (PLA)), polyurethane (PU), polycarbonates (PC) - that are most commonly used in our day-to-day life. Mixed plastic wastes are also frequently generated at the consumer end and are more challenging to address (Song et al. 2022).

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## **10. Conclusion**

The various types of wastes generated from tea (spend tea leaves, paper, plastic, earthen cups, etc.) are one of the most significant carbonaceous biomasses originating from different public places. Tea wastes are available worldwide and are one of the very common agri-food wastes. The valorization of tea waste through chemical and physical activation, carbonization, and extraction results in the formation of value-added products like adsorbent, activated carbon, magnetic adsorbent, and carbon-based nanomaterials including carbon nanodot, graphene oxide dot, etc. These valorized tea waste materials and their hybrids/composites have important applications in the fields of sensing, detection, pollutant removal, separation, wastewater treatment, environmental remediation, catalysis, energy storage and harvesting, tissue engineering, agriculture, food industry, green and sustainable nanotechnology. By considering the aforementioned applications in diverse fields, tea waste has become one of the important parts of agri-food waste, and applications of its valorized products have been systematically summarized in this project report supported by an exhaustive case study.

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## **11. Future Scope of the Study**

Although the study has tried to cover various aspects, however, few scopes of betterment were identified. Those shortcomings and the lacuna for the study have been presented below;

- A more exhaustive survey could have been conducted across different locations of the country, in order to have a real insight into the problem.
- Experimental validation of the different valorization pathways could have been adopted in order to establish the literature-cited routes.
- Conducting various awareness programs and thereby educating people in order to make people understand the adoption of various mitigative routes for overall sustainable development.
- Planning and implementation of proper schemes for the segmentation, collection and management of the various wastes generated from various small, medium, and large-scale tea stalls.

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