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Research Article

Comparative analysis of banana tree waste, cow dung manure, lignite coal co-combustion for reducing pollutants

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ABSTRACT

Combining coal with biomass is the best way to reduce pollution in the environment and contribute to renewable energy sources. The TGA investigation of lignite coal, tree leaves, and their mixes was investigated in this paper. The main objective is to ascertain the thermal properties of coal and tree leaves using the thermogravimetric test. The recommended TGA method makes use of an ambient temperature of 90°C. Temperatures ranging from 105- 110 °C were used to dewater the samples. The greatest amount of volatile matter is attained as you increase the amount of cow dung manure and banana tree waste, and the highest amount of carbon that is fixed (char burning) is LC90+CDM10.There are numerous advantageous conditions for dewatering, devolatilization, and char burning in the lignite coal-to-biomass mixing ratio. The co-combustion of these materials can also minimize waste disposal problems by utilizing agricultural residues effectively. Moreover, it supports the circular economy approach by converting waste into valuable energy. These findings suggest that coal–biomass blends can serve as a transitional energy solution toward fully renewable systems in the future.

1. INTRODUCTION

Pakistan has abundance of coal reserves, new technologies for using coal must be developed. Co-combustion of coal and biomass has drawn a lot of attention in relation to pollution and power generation [1]. Particle diameter ranges (53–75, 106–150, and 150–212 mm) were shown to have a minor impact on the weight loss profile when coal and biomass were burned together [2]. Thermogravimetric analysis showed that a large amount of volatile matter in the wood biomass rapidly emits at low temperatures, which increases the particle surface temperature and improves the reactivity on the outermost part of a low-rank coal and contributes to accelerated ignition currently a lower temperature [3].

The thermal breakdown of biomass, coal, and more recently, sewage sludge, has often been described using thermal analysis. The simplest and most efficient method for observing a fuel's combustion profile is thermogravimetric analysis [4]. The quick evaluation of the fuel concentration, the temperatures at

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which combustion begins and stops, and other parameters like the maximum reactivity temperature, amount of ash, and total combustion duration are the benefits of this study [5]. The calorific value and proximal and ultimate analyses of the materials were described. Under normal heating settings, the combustion behavior of biomass and cellulose–coal blends were examined.

Bituminised coal, aspen straw dust, and wheat straw, both alone and combined with various coal weight ratios, were subjected to thermogravimetric analysis [6]. The study focused on TGA analysis of cow dung manure, banana tree waste, lignite coal, and their mixtures [7]. Because of its enormous potential to minimise environmental pollution, experts have recently recognised the effectiveness of burning coal and biomass. Because coal and biomass are blended, SO2 emissions are reduced [8].

Resolving environmental issues like sickness and global warming is beneficial [9]. In the cement sector, the combination of coal and biomass works well since it helps to solve emissions-related issues [10]. One possible way to turn biomass from trash into a valuable product is by co-burning [11]. By using co-combustion technology, we can produce sustainable energy from wasted biomass [12].

2. MATERIALS AND METHODS

The work at the Chemical Departments of BUITEMS Quetta, Balochistan, Pakistan. The required study materials included lignite coal and tree leaves and their combinations.

Lignite coal

Pakistan may have substantial coal reserves, most of which are lignite coal. Moisture makes up around 44.3% of lignite coal, fixed carbon makes up 19.2%, carbon makes up 51.18%, and ash makes up 6.83%.

Banana tree waste

There are many safe types of trees leaves available globally, and co-combustion was one method of using these without causing environmental damage. The BTW used in this study was gathered from several sites in Jamshoro and Hyderabad.

Cow dung manure

Co-combustion is one environmentally friendly method of using cow dung manure, which is available in many safe variants worldwide. The BTW used in this study was gathered from several sites in Jamshoro and Hyderabad.

Lignite coal and banana tree waste blend.

A laboratory mixer was used to mix coal and biomass to ensure proper mixing. Tree leaves and lignite coal were mixed in different proportions to determine the blend's characteristics.

Lignite coal and cow dung manure blend.

To guarantee adequate mixing, lignite and biomass from coal were combined in a lab mixer. To ascertain the blend's properties, several proportions of lignite coal with manure from cows were combined.

3. METHODOLOGY

For the block diagram below illustrates the technique used for TGA analysis. The first stage in the block diagram below is sample preparation and blending, which includes crushing, grinding, and weighing the material for T.GA analysis. Then, for TGA analysis, we combine various ratios of lignite coal as well as tree leaves (Vuthaluru, 2003). We examine the thermal behaviour of lignite coal plus banana tree waste and cow dung manure using a TGA analyser.

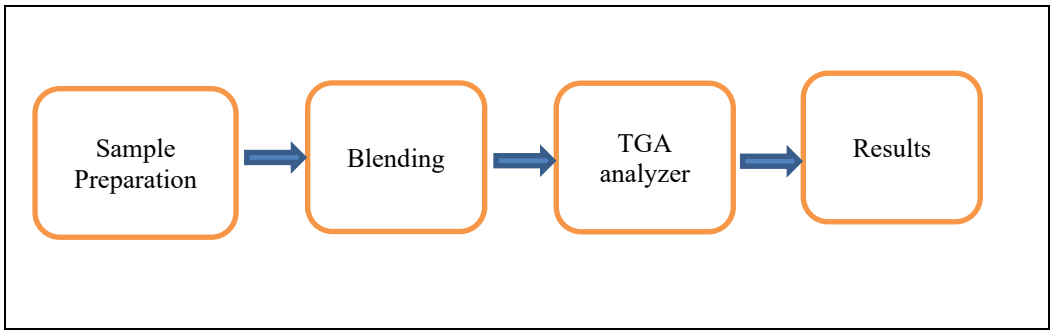


Fig. 1. Methodology for lignite coal and banana tree waste,cow dung manure for TGA analysis.

4. RESULTS AND DISCUSSION

To see how blending ratios affected combustion, several percentages of leaves from trees were used with lignite coal prior to co-combustion. To ascertain the characteristics of anthracite coal and biomass, TGA analysis of lignite fuel, tree leaves, as well as their mixes was being investigated. various combinations of coal, cow dung manure, and banana tree waste to maximise growth conditions for energy supplies for future needs. Compared to the released levels of SO_2, NOx, and CO_2, co-firing had several benefits.

The impact of the ratio from lignite coal to tree leaves upon the devolatilizing process is depicted in Figure 2. To determine which coal to biomass ratio contains the least and most volatile particles, several blending ratios were employed. The elimination of volatile matter is investigated using a TGA analyzer in various temperature ranges. (Song and others, 2013). TL has the highest volatile matter content, whereas LC has the lowest. The blend ratio also affects how coal burns since adding more tree leaves to coal increases the volatile stuff.

Table 01: Chemical Characteristics of Lignite Coal, Banana tree waste and Cow Dung Manure

Parameter	**Average value**		
	Waste from banana trees	**Manure of Cow dung**	**Lignite coal**
Carbon	29.513	38.038	56.773
Hydrogen	3.572	4.671	3.88
Nitrogen	0.112	0.231	0.124
Sulfur	0.138	0.143	4.326

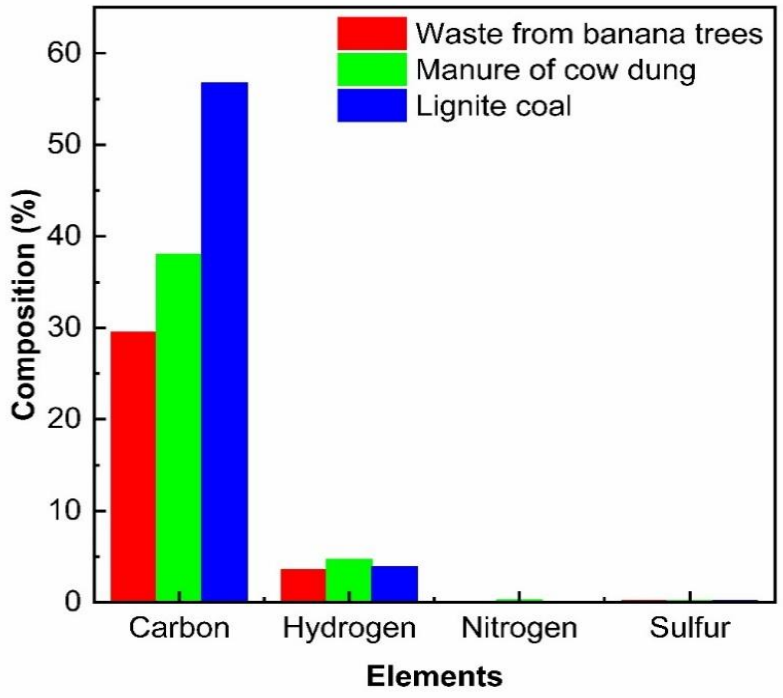


Fig. 2. Chemical Characteristics of Lignite Coal, Banana tree waste and Cow Dung Manure

Table 2: TGA results for cow dung manure and banana tree waste , coal, and their mixtures

Sample no	**Dewatering (°C)**	**Ignition (°C)**	**Volatilization and burning(°C)**	**Transition period (°C)**	**Char burning (°C)**	**Burnout residue (%)**
LC95%+BTW15%	108.47	878	230-530	540-849.59	849.60-851.20	16.54
LC85%+BTW25%	106.88	839.6	190-500	530-849.59	849.59-949.49	17.52
LC75%+BTW35%	105.37	849	220-540	545-848.58	948.59-948.51	16.46
LC65%+BTW45%	105.38	838.5	240-530	500-938	947-948.59	18.29
LC	108.15	856	200-520	600-949.3	949.3-950	15.21
BTW	108.15	855	200-510	590-949.3	949.3-950.3	11.49
CDM	108.15	848	200-480	569-951.3	948.3-951.6	16.76

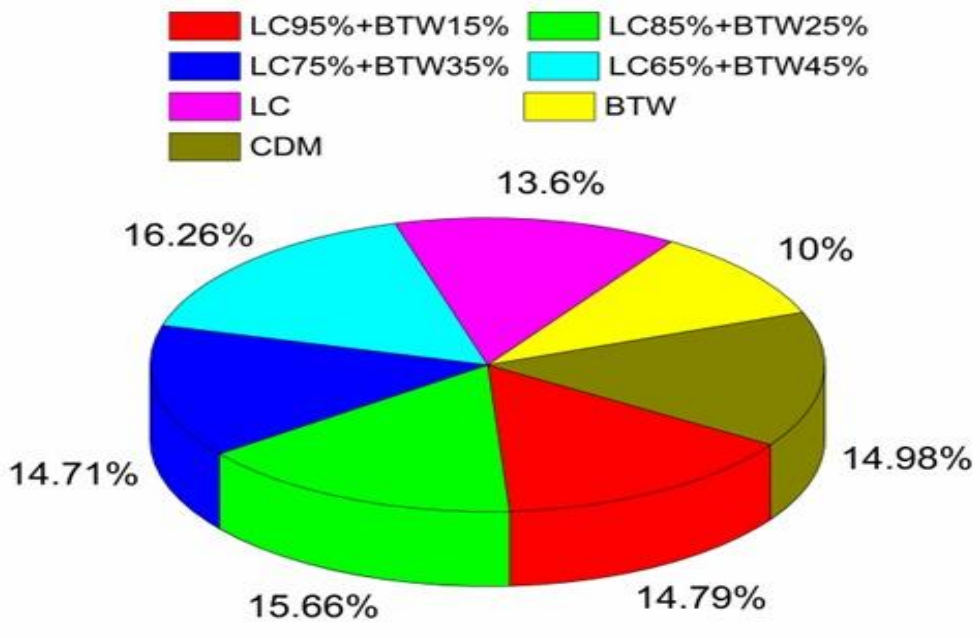


Fig. 3. TGA results for cow dung manure and banana tree waste , coal, and their mixtures

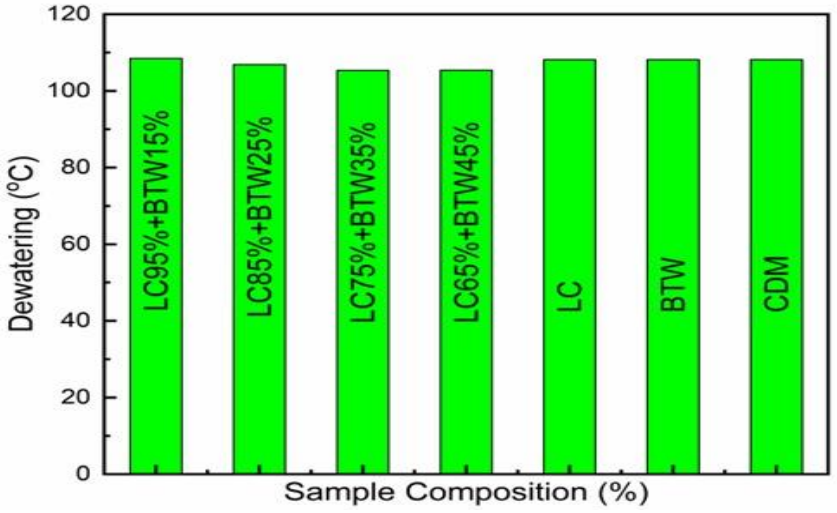


Fig. 4. Dewatering of tree leaves, coal, and mixtures of them

Figure 1 shows the effect of the ratio of lignite coal to tree leaf mixing on dewatering, or the elimination of moisture. Dewatering is the process of removing moisture once the sample has reached the proper temperature for its kind. When using LC70+BTW30% which make it easier for biomass and coals to burn together, the lowest temperature required for removing moisture from samples is around 103 °C, several samples were examined using a TGA analyzer to get pre-processed conditions.

Figure 3 shows how the ratio of lignite coal to bananas tree waste blending affects the removal of fixed carbon. To determine the optimal ratio for coal and biomass co-combustion, several coal and biomass blend ratios were examined. The highest amount of fixed carbon is found in LC and LC90+BTW10, while the lowest percentage is found in BTW.

Figure 4 shows how the tree leaves mixing ratio and lignite coal affect the amount of ash present. The greatest quantity of residue produced by LC80+BTW20 after sample burning is around 28.38%, whereas the smallest amount produced for TL is approximately 11.49%. Because the residue produced is smaller than that of other coal and biomass blends, it indicates that the maximum amount of residue formed when tree leaves are mixed with coal is ideal for TL burnout waste.

Table.3. Heating value of different biomass and coal

S. No	Sample name	Heating value(Btu/lb)
1	LC	720438.9
2	TL	784540.4
3	BTW	819512
4	CDM	722700

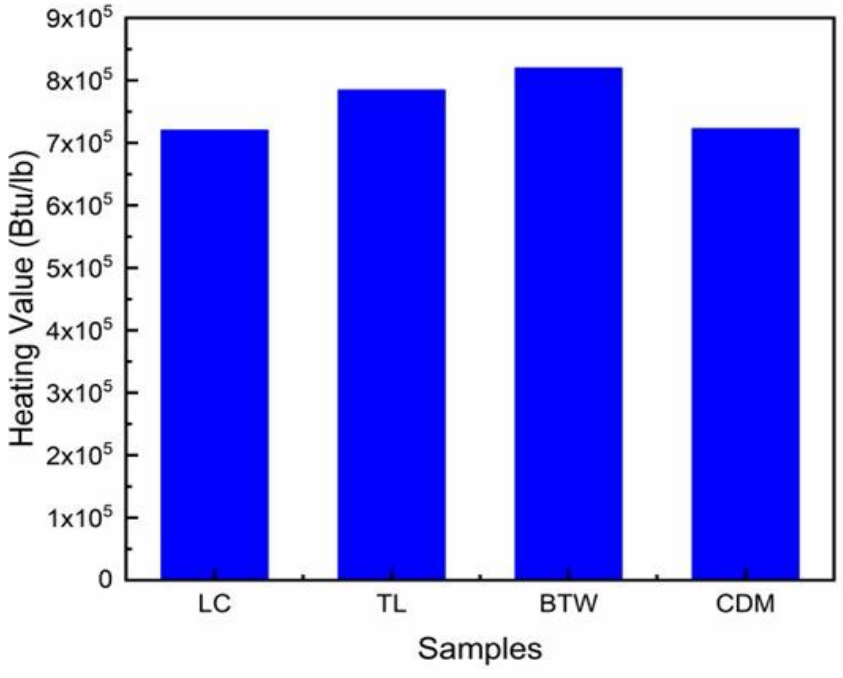


Fig. 5. Heating value of different biomass and coal

The TGA analyzer was to analyze moisture content. For lignite coal (fig.), below about temperature was brought to 108.15^{0}C and maintained for 15.78 minutes. The moisture was found to be 12.21 %. For volatile matter temperature was fixed at 949.030 °C for 39.14 minutes. The amount of volatile matter was observed to be 36.83 % of total mass of coal. For fixed carbon, the temperature was maintained at 950^{0}C for 45 minute and the amount was found to be 35.73 %. The ash was the residue and was observed by calculation of volatile matter. Fixed carbon was found to be 15.21% in total.

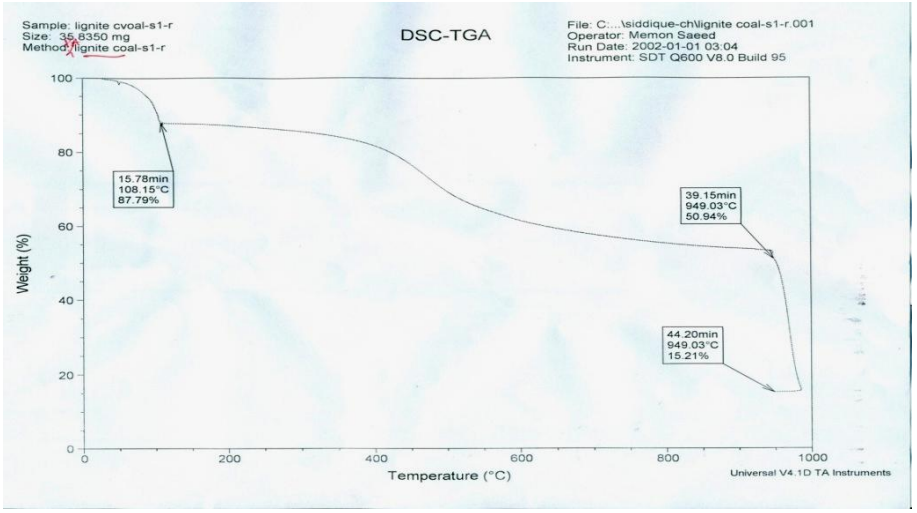


Fig. 6. TGA analysis of lignite coal

For moisture content of banana tree waste, temperature was brought to 108.15ºC and maintained for 10.77 minutes. The moisture was found to be 6.4 %. For volatile matter temperature was fixed at 949.03 ºC for 28.10minutes. The amount of volatile matter was observed to be 68.68 % of total mass of coal. For fixed carbon, the temperature was maintained at 950ºC for 29.42 minute and the amount was found to be 6.27 %. The ash was the residue and was observed by calculation of volatile matter. Fixed carbon, which was found to be 18.65% in total (Fig. 4.15).

For moisture content of cow dung manure, temperature was brought to 108.15ºCand maintained for 10.72 minute. The moisture was found to be 7.25 %. For volatile matter temperature was fixed at 947.54 ºC for 28.77 minutes. The amount of volatile matter was observed to be 63.27 % of total mass of coal. For fixed carbon the temperature was maintained at 950ºC for 31.23 minute and the amount was found to be 12.81 %. The ash was the residue and was observed by calculation of volatile matter. Fixed carbon which was found to be 16.67% in total (fig. 4.16)

Restrictions & Upcoming Work

Co-combustion of biomass is the result of economic and technological considerations. There are certain restrictions on this coal and biomass co-combustion method. This technology's technical drawback is that the design of the combustion process depends on a certain fuel ratio. On the other hand, their burners are made to account for volatile elements including water, ash, sample size distribution, and dust levels. In order to develop a novel system with the given characteristics, biomass must be co-fired.

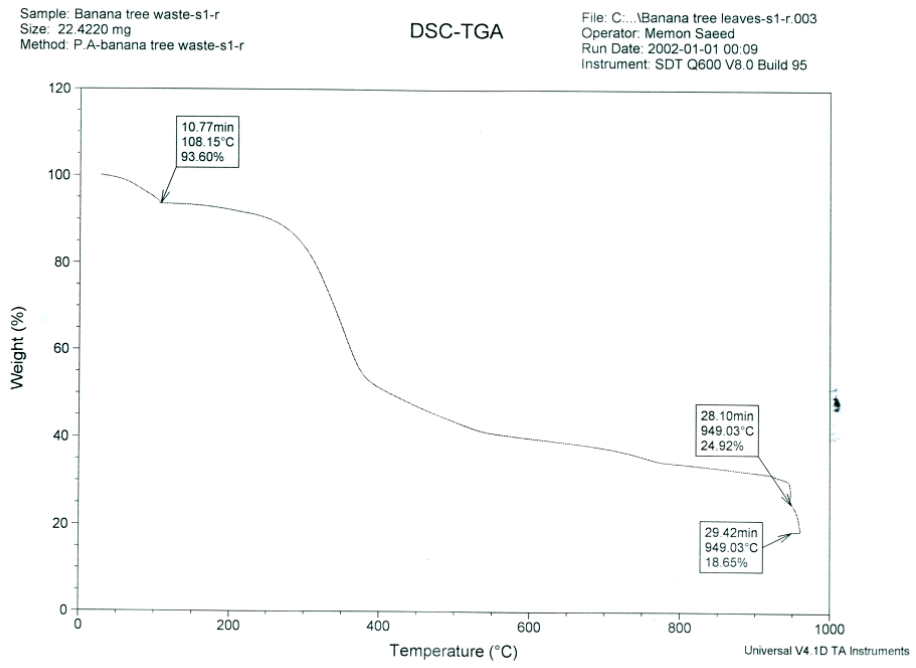


Fig. 7. TGA analysis of Banana tree waste

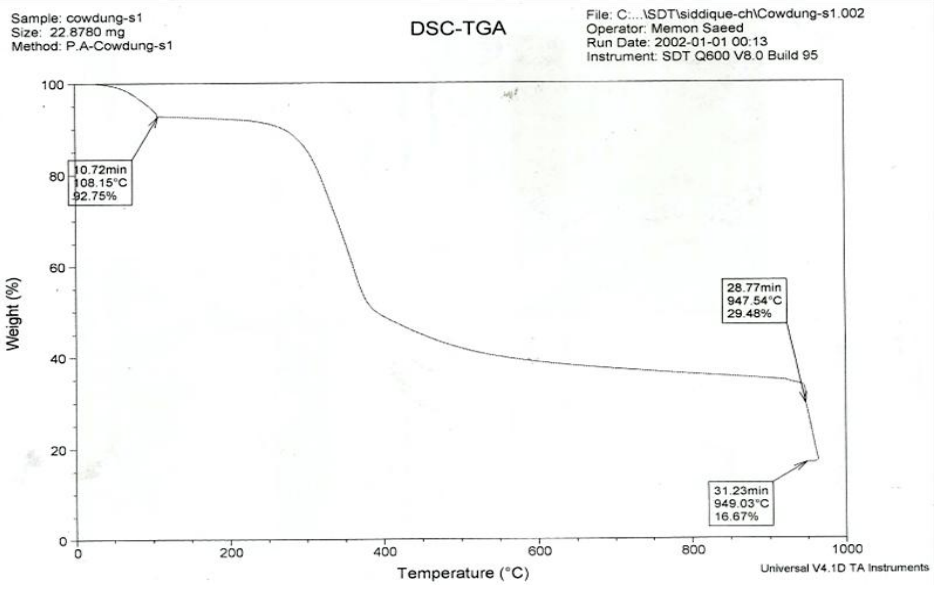


Fig. 8. TGA analysis of cow dung manure

5. CONCLUSION

Blends of coal and biomass have a big impact on co-combustion. Different things were seen when coal and biomass were burned when TGA tests. The lowest temperature needed for LC70+BTW30 is around 105ºC, and the quantity of moisture removed is between 105 and 110 °C. The minimum quantity of volatile chemicals in LC is around 36.85%, whereas the highest amount in TL is approximately 73.01%. The minimal quantity of fixed carbon in TL is around, and the highest amount in LC90+TL10 is approximately. LC80+CDM20 produced the most burnout residue, whereas BTW produced the least. It has been determined that using BTW, CDM in conjunction with Lignite coal offers several advantages for coal co-combustion.

Declarations
Conflicts of Interest
The author declares no conflicts of interest.
Funding
This research received no external funding.
Data Availability Statements
The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

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