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NEW APPROACH TO GARDEN WASTE TREATMENT WITH ADDITIVE BASED COMPOSTING

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Abstract:

The growing world population and the resulting higher consumption of products and services has driven a rapid increase of organic wastes originating from households, industry and agriculture. Biological degradation during composting is one of the strategies to transform organic wastes into organic products. Hence, a considerable research in the field of rapid composting is to be done so as to accelerate the composting process. Study was executed with lab scale experimental setup and performed using Plastic Bins for composting in size of 20 cm diameter and 25 cm deep. A comparative study between Normal Composting (control) and Additive based Composting (AbC) was done. The various additives utilized in the current study include Jaggery, Lime, Fly ash and Bioculture in combination of two additives keeping Jaggery constant. The composting parameters including pH, temperature, C/N ratio and electrical conductivity were monitored at a regular interval for a period of 40 days. Changes in physical characteristics (particle size distribution) of the waste throughout the composting process were also examined. The results obtained from the current study revealed that AbC facilitated Jaggery-Bioculture and Jaggery-jaggery have optimum performance than others as indicated by quick rise in temperature and C/N ratio below 20. The utilization of additives in combination reduced the composting time by a minimum value of 25% as additive based composting required 28 days whereas control unit took 40 to attain C/N ratio below 20. A positive effect of doubling the amount of jaggery was seen by accelerating the composting process enabling microbial activity due to good source of food. The compost quality examined with help of different parameters suggests and favoured in use of Jaggery-Bioculture and Jaggery-jaggery combination for optimum and rapid composting of garden waste. The future studies can focus on using suitable techniques to be merged and exploring different combinations with different proportions of additives in order to generate a new technique which will be beneficial for reducing the duration of composting with variety of waste categories.

***Index Terms*: Additive based Composting (AbC), Bioculture, Garden waste, Rapid composting**

I. INTRODUCTION:

Growing concerns relating to land degradation, the inappropriate use of inorganic fertilizers, atmospheric pollution, soil biodiversity, soil health and sanitation have shifted global interest in organic recycling practices such as composting. Urban India (about 377 million people) generates 62 million tonnes of municipal solid waste (MSW) each year. Of this about 43 million tonnes (70%) is collected and 11.9 million tonnes (20%) is treated. About 31 million tonnes (50%) is dumped in landfill sites. According to a 2014 India Planning Commission MSW study, 51% of MSW was organic or biodegradable, 32% is inert or non-organic and 17% is recyclable waste. Collected waste is often dumped in open land or used for landfilling. Due to the scarcity of land, existing dumping yards are sometimes overfilled. Although incineration is increasingly being used for waste disposal, it cannot be advocated widely due to the associated toxic gas emissions. Composting is an ancient technology, practiced today at every scale from the backyard compost pile to large commercial operations. It is the natural biological process in which degradable part of waste is transformed to a stable material with excellent characteristics for application on soils. In accordance with the last trend of environmental policies, composting is a valuable way of waste treatment that contributes to reduce organic waste destined to landfill disposal or incineration. However, recent days have witnessed a renewal of interest in composting due to the advancements in composting technology. Hence, an effective composting method, which enables the production of good quality compost at an economical cost, can only meet the criteria for sustainable organic soil management. Composting is a time consuming process including degradation of waste by the microbial population converting them into a stable organic fertilizer. Hence, a considerable research in the field of rapid composting is to be done so as to accelerate the composting process. The current work utilizes the

aerobic method of composting for the effective treatment of garden waste generated. An effort is being made to reduce the composting time by utilizing combination of additives and techniques. Various additives utilized were jaggery, bio-culture, fly ash, lime will be adopted and the composting parameters were monitored for a period of 40 days. Improvements in composting process control will help increase the efficiency and economic viability of the related technologies, and thus contributing to agricultural and societal sustainability. The current study aims to reduce the duration of composting by utilization of Combination of additives (Jaggery, Bio-culture, Lime and Fly ash) with Garden waste. A comparative study analysis between normal composting (control) and Additive based Composting (AbC) is performed.

II. SYSTEM DEVELOPMENT:

2.1 Raw waste and additives:

The garden waste (GW) mainly consisting of grass trimmings and fallen leaves collected from the garden of was used as raw material for composting. The collected waste was then shredded by using the shredder machine for reducing the volume of waste. It is expected that combination of certain additive able to give desired result for rapid composting of garden waste and those combination of two additives derived out of observation and results of past research work done suggested that Jaggery has better efficiency of treatment than other ingredients so keeping jaggery constant in combination and changing second additive ingredients in composting process and they are 1) Jaggery + Bio culture (JB) 2) Jaggery + Fly Ash (JF) 3) Jaggery + Lime (JL) 4) Jaggery + Jaggery (JJ) in combinations.

2.2 Experimental setup :

For the experimentation the raw waste was collected, processed and then subjected to composting process and is done using Plastic bin of 2 kg Capacity in 2 sets of trial with 10 number of units containing different combination feeding into it. A comparative study of composting is done by utilizing various combination of additives and techniques to the collected waste for accelerating the composting process. The composting bins were filled with shredded waste and 5% of each combination of additive was added on dry weight basis. One of the bin in composting is treated as blank unit (i.e. no additive will be added). The composting bins are divided into 2 set with 5 numbers of composting bin, in which 4 different additives are added. In this way the comparative study for various combination of additives can be done and the best additive giving the optimum results can be determined.

2.3 Characterization of waste and analysis:

The particle size distribution of raw waste was done by sieve analysis using sieves of 12 mm to 2 mm mesh sizes for 5 min and cumulative percentage passing (CPP) through 12 mm was calculated as:

$$CPP = 100 - \%\ retention \quad (1)$$

$$CPP = 100 - \frac{Weight\ of\ sample\ retained\ in\ sieve}{Total\ weight\ of\ sample} \quad (2)$$

The chemical analysis was performed on oven dried powdered samples in the laboratory. pH and Electrical Conductivity (EC) was measured by mixing 1 gram of powdered sample with 10 ml of distilled water for 15 min. The carbon and nitrogen content was determined using Mridaparikshak testing equipment developed by Indian Institute of Soil Science. All the analysis were carried out in two trials and the mean values with standard deviation was calculated using Microsoft excel. Graphical representations of pH, Temperature, C/N ratio, EC were also statistically interfaced with error bars.

III. RESULTS AND DISCUSSIONS:

3.1 Characterization of Raw waste :

The collected raw waste was shredded and then initial testing was done to determine physical and chemical parameters. Small portion of the waste was oven dried and chemical testing including pH, EC and C/N ratio. Physical characteristics including particle size distribution by sieve analysis. The results of gradation test on the raw waste it was inferred that CPP through 12 mm sieve size was 52.38 %. Initial C/N ratio of the raw waste was found to be 28.40 (optimal range i.e. 20-40). MC was found to be 58% (optimum range of 40-60% for start of the compost process). The average pH and EC were measured as 5.80 and 1.80 dS/m.

3.2 Characterization of waste mixed with Combination of additives:

Various combination of additives in a decided proportion (5%) were added to the shredded waste as mentioned earlier. The characteristics of the raw waste mixed with these additives are tabulated in Table 3.1. The C/N ratio in all treatments was found to be in the optimal range for the initial composting process.

Table 3.1: Initial characteristics of the waste mixed with additives

Parameters	JB	JJ	JL	JF
pH	6.9 (0.2828)	6.15 (0.2121)	11.65 (0.2121)	9 (0.4242)
EC (dS/m)	1.81 (0.1272)	1.98 (0.0494)	1.7 (0.0281)	2.05 (0.2121)
C/N ratio (%)	27.25 (0.212)	32.4 (0.1414)	28.65 (0.4949)	28 (0.2828)

3.3 Effect of additives on Temperature profile during composting process:

Temperature is one of the important parameter to assess the progress of composting process as it shows the heat released by the metabolic activity of the microbes .The change in temperature throughout the composting process is illustrated with graph in Fig. 3.1. The temperature in starting for case of addition of Jaggery-Lime (JL) was maximum compared to control and other additives combinations. Due to the exothermic reaction of jaggery-lime with water, the average initial temperature observed was 31.25°C. The maximum mean temperature in thermophilic phase (TP) observed in case of jaggery-bioculture (JB) and jaggery-jaggery (JJ) treatments were 54.7°C and 55.1°C respectively on 7th day. Due to the presence of effective microorganism (EM) required for composting process in initial stage maximum increase in temperature occurred in case of Jaggery-bio-culture treatment than other combination and control. Whereas the early rise in temperature in case of Jaggery-jaggery treatment compared to control unit and other treatments could be due to the availability of food (carbon source) to the waste degrading microbes that enhanced their growth leading to increase in metabolism activity and heat.

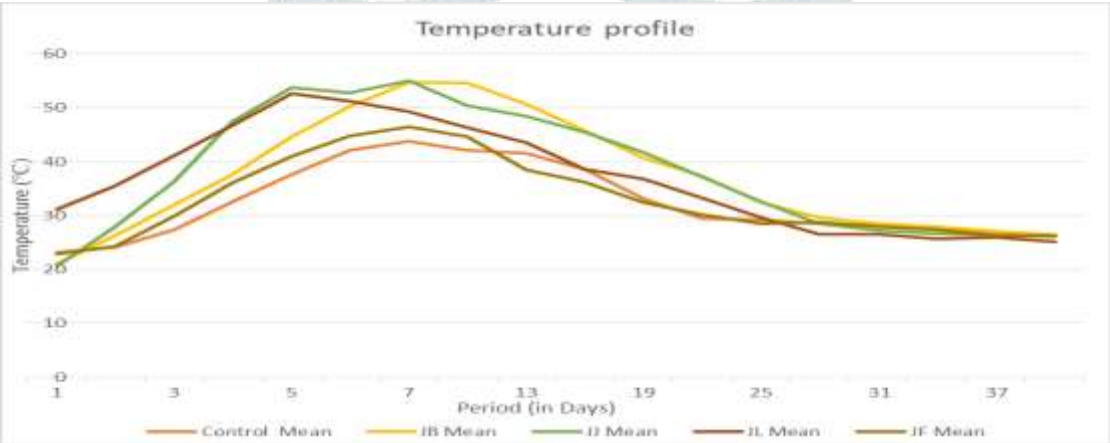

Fig.3.1: Effect of additives on temperature profile during composting process.

3.4 Effect of additives on pH during composting process :

The effect of different additives during the composting process is tabulated in Fig. 3.2. The initial mean pH in all treatments was in the range of 5.9 to 6.15, excepting jaggery-lime and jaggery-fly ash treatment had 11.65 and 9.0 respectively. During the initial days the pH started increasing from acidic to neutral level in case of control unit, jaggery-bioculture and jaggery-jaggery treatment. In jaggery-lime and jaggery-fly ash treatment the pH decreased from basic level up to neutral level. Jaggery-Bio-culture and Jaggery-jaggery treatments maintained low pH below 7.6 value throughout the composting period, probably due to the enhanced action of microbes generating acidic substrates.

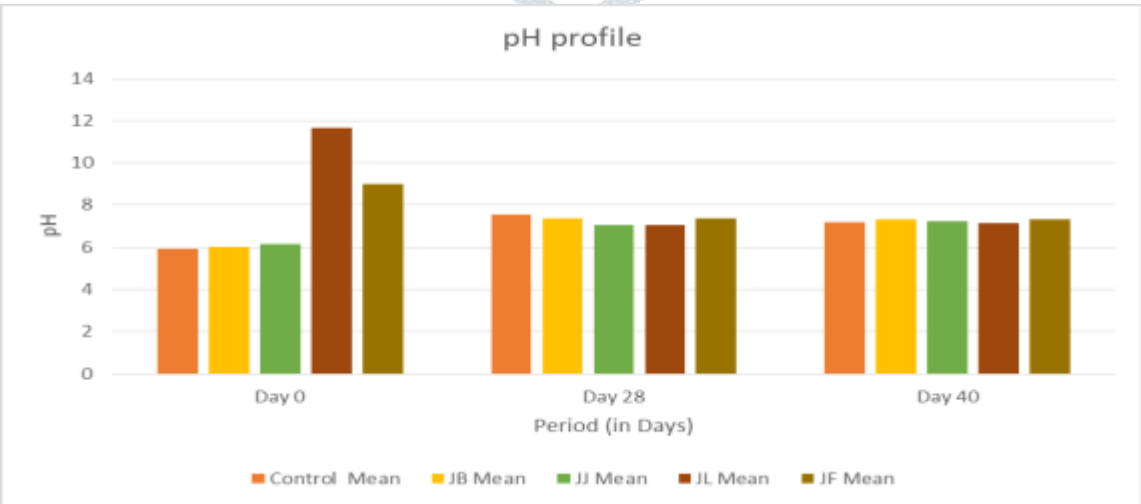

Fig.3.2: Effect of additives on pH during composting process

3.5 Effect of additives on EC during composting process :

The determination of EC of compost sample is beneficial as it indicates salt concentration of a sample and influences its use as a fertilizer after composting. The precipitation of mineral salts presents as the organic matter degrades resulting in higher pH values. In the current work, initial value of mean EC of waste was in range of 1.81 to 2.05 dS/m. Due to the degradation of organic matter by activity of microorganisms converting it into mineral salts the mean EC was increased to 3.16 dS/m in case of jaggery-bio-culture. Maximum EC was observed in case of jaggery-fly ash treatment due to presence of high initial concentration of minerals at the starting of composting process. Value of EC greater than 4 dS/m is not advisable for using as soil conditioner. Figure 3.3 shows variation of EC throughout the cycle of 40 days.

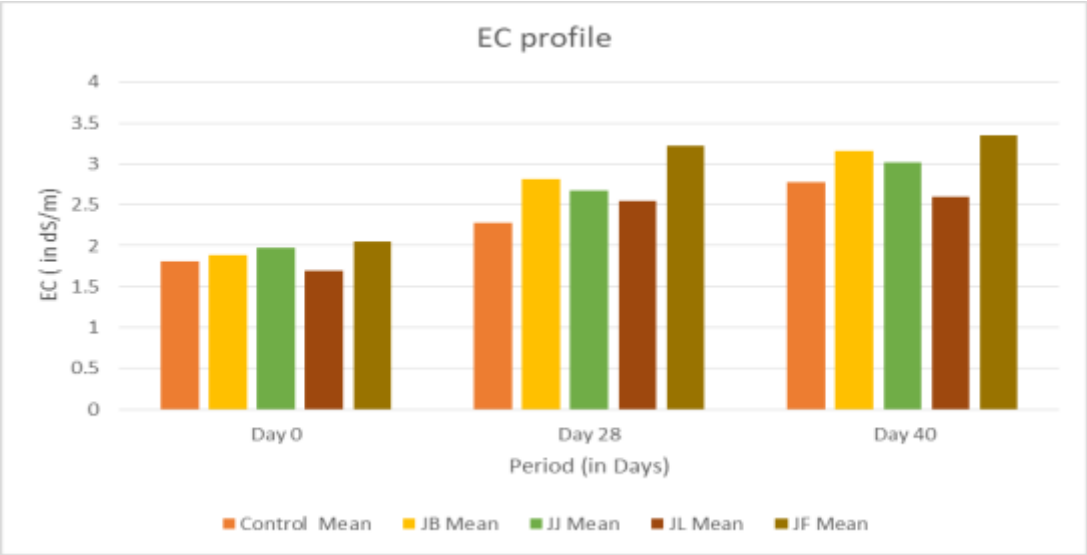

Fig.3.3: Effect of additives on EC during composting process.

3.6 Effect of additives on C/N ratio during composting process :

The variation of additives for C/N ratio is illustrated in Fig. 3.4. C/N ratio was found to be less than 20 in all AbC whereas it took 40 days for control unit to attain C/N ratio < 20. Maximum reduction in C/N ratio on 40th day was observed in case of jaggery-bioculture (10.0) followed by jaggery-jaggery (12.15). The reduction rate of C/N ratio on 40th day was found to be 63.30%, 62.50%, 37.03% and 36.85% in case of jaggery-bio-culture, Jaggery-Jaggery, Jaggery-lime and Jaggery-fly ash respectively. Whereas, a reduction of 28.72% in C/N ratio was observed on 40th day in case of control unit.

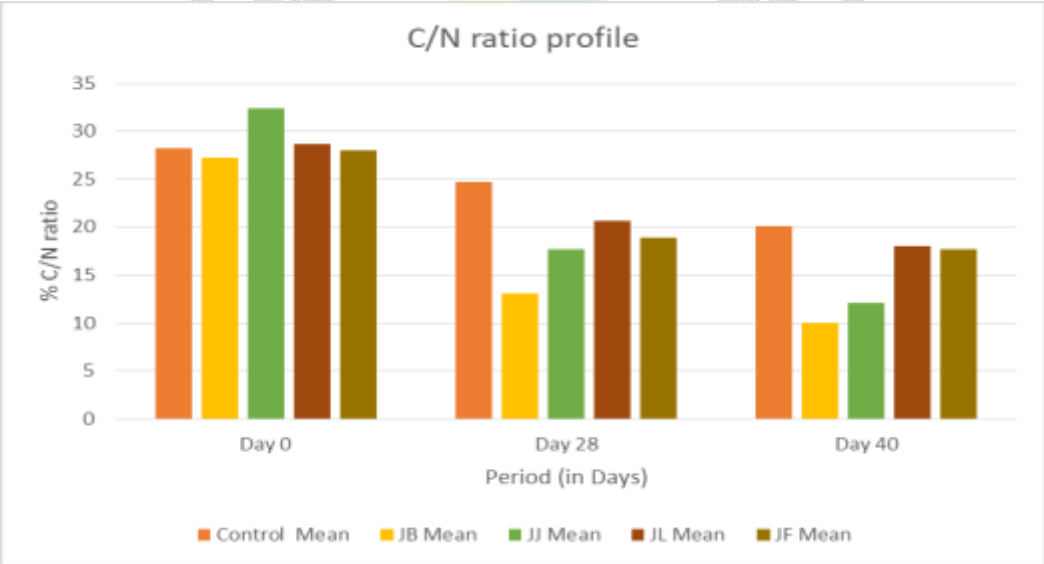

Fig.3.4: Effect of additives on C/N ratio during composting process

3.7 Effect of additives on Particle size distribution during composting process :

Sieves of size 12 mm to 2 mm were used to fractionate the material to calculate CPP and the results are presented in Fig.3.5. Ideally, best compost should have 90% cumulative percentage passing (CPP) through 12.6 mm sieve. The compost with cumulating passing more than 15 mm sieve is not to be applied into field. The results showed that CPP through 12 mm sieve size was greater than 90% in all the treatments. Particle size reduction was observed maximum in case of jaggery-bio-culture followed by jaggery-jaggery than any other combination and control treatments. This parameter was tested on initial (day 0) and after completion of treatment (day 40).

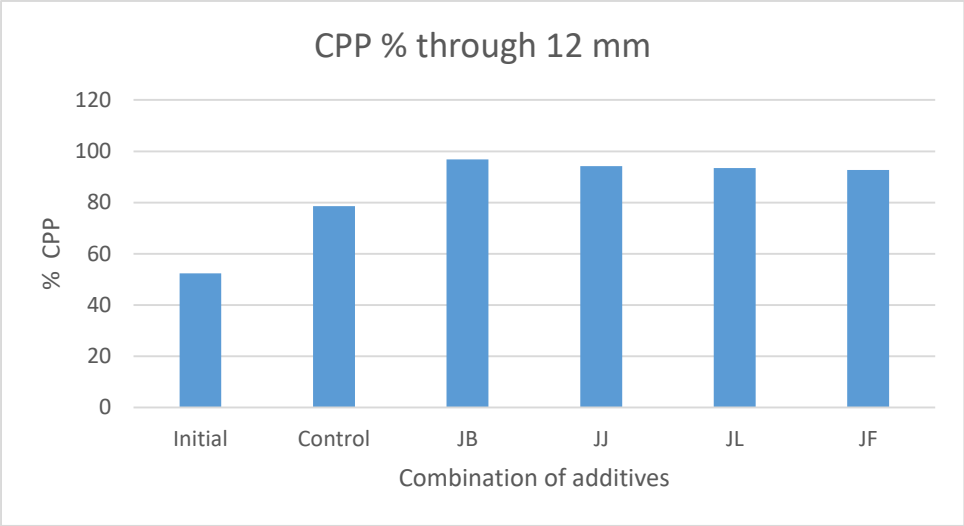

Fig.3.5: Variation in PSD in Final compost after composting process (Day 40)

3.8 Characteristics of final compost:

The final compost samples were characterized and compared with the standards mentioned in Solid Waste Management Rules (2016) as illustrated in Table 3.2. In case of final compost obtained by AbC all the mean values of pH, EC and C/N ratio were 7.15-7.3, 2.59-3.34, 10-20.1 which were found to be within the prescribed limit for the final compost. Control contained C/N ratio of 20.11 which was not per the SWM standards. The current study helped for the comparative analysis of whole composting process carried out by utilizing various combination of additives. The production of good quality compost attained in less period achieving rapid waste composting according standards of SWM rules 2016 for the final compost. These characteristics of final compost from treatment were compared with control values at initial day and day 40 after completion of composting of garden waste.

Table 3.2: Comparison of final compost parameters with standard values as per SWM Rules 2016 (Day 40)

Parameters	Control (Day 40)	JB (Day 40)	JJ (Day 40)	JL (Day 40)	JF (Day 40)	SWM rules 2016	Control (Day 0)
pH	7.2 (0.1414)	7.3 (01414)	7.25 (0.2121)	7.15 (0.0707)	7.3 (0.2828)	6.5-7.5	5.8
EC (dS/m)	2.77 (0.0424)	3.16 (0.0565)	3.02 (0.1414)	2.59 (0.0212)	3.34 (0.0919)	≤4	1.8
C/N (%)	20.1 (0.4242)	10 (0.2828)	12.15 (0.3181)	18.04 (0.3878)	17.68 (0.1767)	≤20	28.4
Colour	Fair Black	Black	Fair Black	Brown	Brown	Dark Brown to Black	Green
Odour	Absent	Present	Absent	Absent	Absent	Absence of Foul Odour	Absent
% CPP	78.56	96.81	94.23	93.48	92.65	More than 90% CPP	52.38

3.9 Discussions

The present study demonstrated the comparative analysis of whole composting process for period of 40 days carried out by utilizing various combination of additives. The production of good quality compost was obtained in less duration achieving rapid waste composting. The final compost samples were characterized and compared with the standards mentioned in Solid Waste Management Rules (2016). Among the different additives the maximum reduction in C/N ratio obtained in case of Jaggery-Bio-culture indicated the rapid composting process followed by jaggery-jaggery. Jaggery-Bioculture combination favoured optimum result oriented combination than any other combination and responsible achieving rapid composting. On the other hand, jaggery-lime and jaggery-fly ash did not show any negative effect on composting process but enhanced the composting process compared to the control treatment. Hence, the utilization of additives in the composting process hastened the composting process achieving rapid composting. Considering the compost parameters throughout the composting process Jaggery-Bioculture and Jaggery-Jaggery are the most effective and optimum combination of additives suggested for rapid composting of garden waste compared to Jaggery-Lime , Jaggery-Flyash and Control treatment.

IV. CONCLUSIONS:

The current research work was undertaken to assess the effect of various combinations of additives on composting process for the treatment of garden waste. The technique of shredding of raw waste was beneficial for reduction in the volume of raw waste. The comparative study among various combination of additives inferred that utilization of Jaggery-Bioculture facilitated rapid composting process followed by Jaggery-Jaggery. It is observed that Addition of additive ingredients has increased rate of decomposition resulted in rapid composting of waste. Doubled amount of Jaggery leads to better decomposition of waste compared to control unit as it provided good source of food to microbes and indicated by rise in temperature and C/N ratio below 20. The additives used in the study reduced the composting time by a minimum value of 25% as additive based composting required 28 days whereas control unit took 40 to attain C/N ratio below 20. The treatment efficiency determined by decrease in carbon content and increase in nitrogen content (reduction in C/N ratio) was found to be maximum 63.30% in case of Jaggery-Bioculture followed by 62.50%, 37.03% and 36.85% in case of Jaggery-Jaggery, Jaggery-Lime and Jaggery-fly ash respectively. The overall quality according to the compost parameters shows that the utilization of combination of additives and technique does not produce any negative effect on the composting process rather it enhances the composting process. For the rapid composting of garden waste, it can be suggested that Jaggery-Bioculture and Jaggery-jaggery are the optimal combination of additives as these additives containing carbon source helpful to enhance microbial activity. For future studies, this technique and approach will be helpful for treatment of garden waste with different combinations and proportions of additives also changing waste category with same combinations of additives as well as exploring different types of additives for variety waste categories which will be beneficial and helpful achieving rapid composting.

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