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Physical properties of cattle dung

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Abstract
The physical properties of the available cattle dung were determined. The moisture content of the available cattle dung was found to range between 71 to 78% approximately. The total solids concentration is determined to be between 19 and 24%, with a moisture level of 71 to 78%. The bulk density of the cattle dung, which weighed around 1.02 to 1.04 kg and had a TS level ranging from 20 to 27%, ranged from 1009 to 1030 kg/m3. The static coefficient of friction of dung samples dried in the sun for five days was determined to be between 0.69 and 0.81. The static coefficient of friction of dung samples dried around 20%, 30%, and 40% was 0.79, 0.73, and 0.712, respectively. The dynamic viscosity of the fresh cattle dung sample having different dung and water ratios as 1:1, 1:0.75, 1:0.50, 1:0.25, 1:0 was 184, 922, 1260, 3280, 5890 mPa·s, respectively.

Keywords: Cattle dung, moisture content, total solid concentration, static coefficient of friction, viscosity

Introduction
India is a distinguished country endowed with a diverse herd of indigenous cattle consisting of 50 distinct varieties. As per Livestock Census (2019), the overall cattle population in the country is 192.49 million. It is estimated that that about 69.9% of rural population lives in this country. These bovine animals are domesticated by many rural homes for a variety of reasons. Majority of rural population ensure their livelihood by breeding these cattle animals. Every day, these animals generate a tremendous amount of dung. A cow on an general basis excretes 18-30 kg of dung per day (Parihar *et al.*, 2019). This dung is collected twice a day by these dairy farmers. 1200 million tonnes of livestock manure are generated each year. Cattle dung is termed as a by-product if it is used in other ways, such as a bio-renewable resource (Brown, 2003). It is also employed as a by-product in agriculture as manure, biofertilizer, biopesticides, and an energy source (Dhama *et al*. 2005). Individuals in Indian villages use dry cattle dung in the form of cake for cooking purposes by direct combustion. It is used for plastering of walls and floors in rural houses, which provides insulation during the winter and summer seasons. The burnt cattle dung creates smoke which is used as a mosquito repellent and subsequent ash as a cleaning agent for kitchen utensils. As a result, the numerous uses of cattle dung by village communities represent the indigenous knowledge associated with it. According to ayurveda, it is used as a purifier for all the waste present in nature (Randhwa and Khullar, 2011). Dung produced from 3-5 cattle/day can operate a simple 8-10 m3 biogas plant that can produce 1.5-2 m3 of biogas per day that is suitable for a 6-8 member family, can cook a meal for 2 or 3 times or it can light two lamps for 3 hours or run an all-day refrigerator.

Materials and Methods
The present study was conceptualized to observe and evaluate the physical properties of cattle dung from the dairy barn. Fresh samples of cattle dung were collected from the dairy barn at SV College of Agricultural Engineering and Technology & RS, Faculty of Agricultural Engineering, IGKV, Raipur. A study was done on physical properties of the cattle dung in the Department of Farm Machinery and Power Engineering, Raipur. The total amount of moisture present in a material is determined under prescribed conditions and expressed in percentage of the weight of the moist specimen, that is, the original weight comprising the dry substance plus any moisture present. To determine the moisture content of samples of different cattle dung, it was weighed and kept in the oven at 105 ˚C for 24 hours (ASAE, 2002). The solid was collected as a residual after heating the experimental sample at 105 ˚C till constant weight was achieved. The bulk density of the cattle dung was determined by the method as per IS: 2720 (part XXVII).

This involved filling the measuring cylinder of 500 ml with cattle from a height of 15 cm and then weighing the contents. The weight of the filling contents was calculated by subtracting the weight of the empty cylinder from the height of the cylinder when filled with the dung. The Coefficient of friction was determined as per Indian standards (IS: 8972, 1978). An inclined plane apparatus was designed and built to measure the static coefficients of friction of cattle dung. The cattle dung sample was kept in a rectangular frame so that only the sample and the inclined surface were in contact. A rotational viscometer was used to measure the viscosity of the different slurry samples, i.e., cattle dung: water ratio samples. It consisted of a cylinder in which the sample was poured (18ml). Then LCP cylindrical spindle was used to determine the viscosity. The spindle was rotated in a pool of slurry samples in the cylinder. These varying samples having different weights were experimented with to observe the physical properties and behaviour of moisture content, total solids, and bulk density. A batch of cattle dung was collected and sun- dried for five days to observe the behaviour of the static coefficient of friction. Three fresh samples of cattle dung were collected and dried for different moisture content percentages. These samples were again tested for values of static coefficient of friction. Five different samples were prepared with different cattle dung and water ratio to obtain the values of dynamic viscosity. This experiment gave insight into the behaviour of dynamic viscosity and angle of repose with different consistency of cattle dung and water.

Fig 1: Sample collection of cattle dung

Results and Discussion

Total solid (TS,%) for five samples of cattle dung was found 22.464, 19.3, 20.6, 21.86, and 23.7, respectively. The corresponding moisture content (w.b,%) of 77.536, 80.7, 79.4, 78.14 and 76.3 was found for five samples, respectively. The best polynomial equation obtained to satisfy the curie for moisture content, and different total solids concentration is:

$$y = - 1.2071x2 + 51.975x - 482.01 \quad (1)$$

$R^2 = 0.8191$

Where,
y is the moisture content,%
x is the total solids concentration,%

The equation shows that as the rate of 'x' increases, the rate of 'y' decreases. Therefore, the coefficient of multiple determination was 0.8191.

The bulk density was found between 1010 - 1031 (kg/m3) for fresh samples of cow dung. The highest value of bulk density was found 1030.4 kg/m3 having a major moisture percentage. As expected, the bulk density of dairy cattle dung decreases as the amount of water present in the product diminishes. The bulk density of 1010.8, 1030.4, 1016.32, 1009.1 and 1020.6 (kg/m3) was observed at TS (%) of 21.4, 27.36, 24.52, 20.66 and 25.2, respectively. The best polynomial equation obtained to satisfy the curie for bulk density and different total solids concentration is:

$$y = 0.3935x2 - 15.78x + 1167.6 \quad (2)$$

$R^2 = 0.9927$

Where,
y = Bulk density
x = Total solids concentration

The equation shows that as the rate of 'x' increases, the rate of 'y' also increases. Therefore, the coefficient of multiple determination was 0.9927.

The static coefficient of friction tested consecutively for five days was 0.81, 0.74, 0.72, 0.706, and 0.69. The angle of internal friction was found 79.2˚, 64˚, 44˚, 39˚ and 34.6˚ respectively. The three samples of fresh cattle dung, which were dried 20%, 30%, and 40%, had a static coefficient of friction of 0.79, 0.73, and 0.712, whereas the angle of internal friction was 38.3˚, 36.1˚ and 35.4˚ respectively. The polynomial regression between T.S (%) and Static coefficient of friction of metal sheet is shown in fig 4.3. The best polynomial equation obtained to satisfy the curie for total solids concentration, and static coefficient of friction is:

$$y = 0.0081x2 \; R^2 = 0.9669 - 0.0763x + 0.8724 \quad (3)$$

Where,
y = Total solids concentration
x = Static coefficient of friction of metal sheet

The equation shows that as the rate of 'x' increases, the rate of 'y' decreases. The coefficient of multiple determination was 0.9669.

The polynomial regression between the static coefficient of friction of metal sheet and different moisture content drying percentages is shown in fig 4.4. The best polynomial equation obtained to satisfy the curie for static coefficient of friction and moisture content drying percentage is:

$$y = 0.0002x2 - 0.0165x + 1.036 \quad (4)$$

$R^2 = 1$

Where,
y = Static coefficient of friction of metal sheet
x = Moisture content drying percentage

The dynamic viscosity (mPa•s) were found 5890, 3280, 1260, 922 and 184 for the mixture of cattle dung and water in the ratios of 1:0, 1:0.25, 1:0.50, 1:0.75 and 1:1, respectively. The best polynomial equation obtained to satisfy the curie for different cattle dung: water ratio is:

$y = 112.94x2 - 4861.5x + 52512$ (5)
$R^2 = 0.9399$

Where,
y = Dynamic viscosity
x = Total solids concentration

The equation shows that as the rate of 'x' increases, the rate of 'y' also increases. Thus, the coefficient of multiple determination was 0.9399.

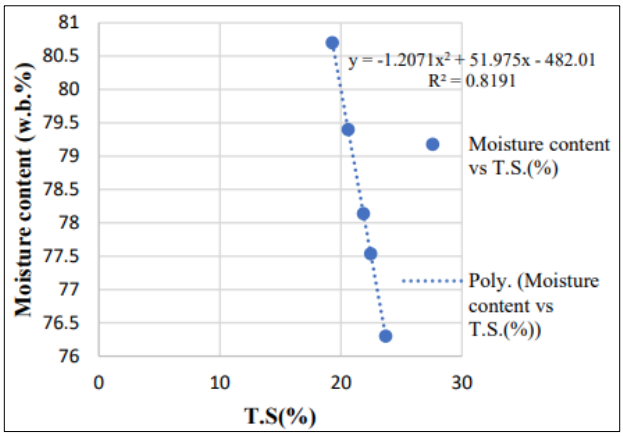

Fig 2: Moisture content vs T.S. (%)

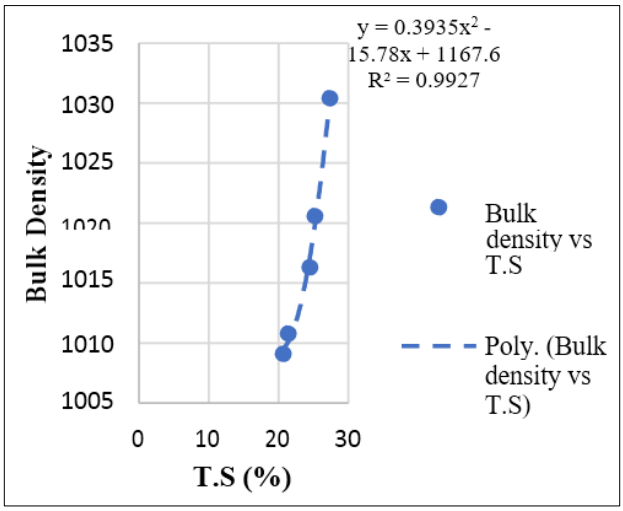

Fig 3: Bulk density vs T.S

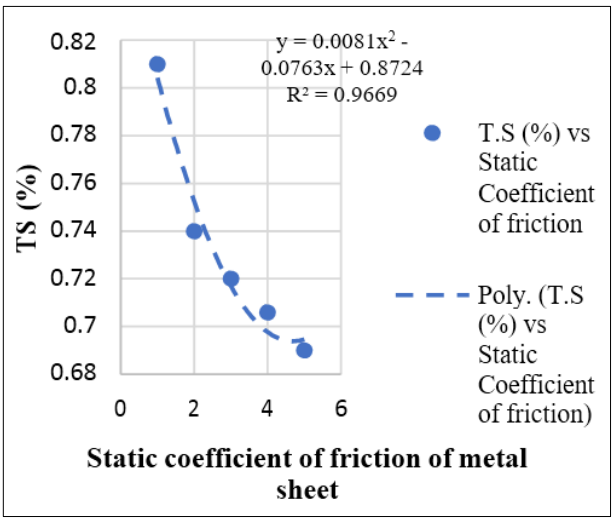

Fig 4: T.S vs static coefficient of friction

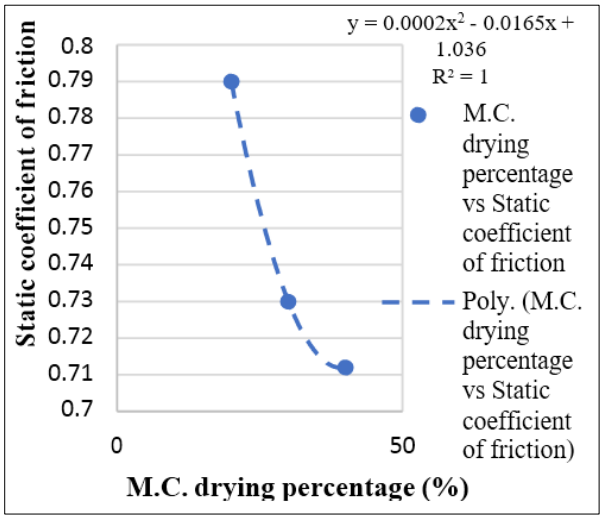

Fig 5: Static coefficient of friction vs M.C drying percentage

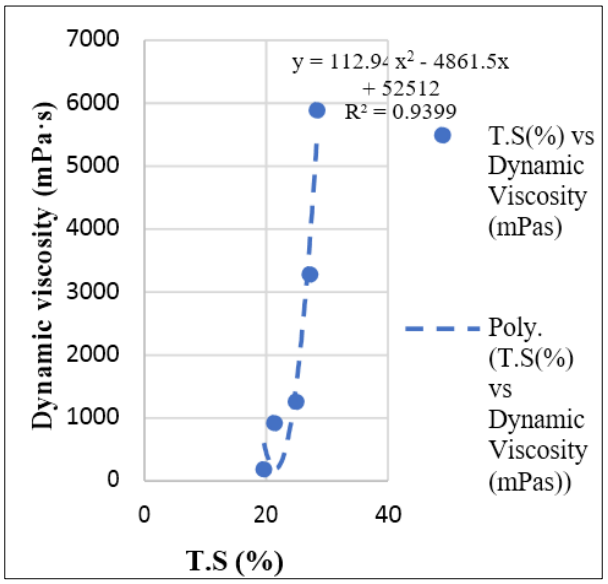

Fig 6: T.S (%)

Conclusion

The moisture content of the available cattle dung was found to range between 71 to 78% approximately. The total solids concentration at a respective moisture content between 71 to 78% are found to be between 19 to 24%. The bulk density of the cattle dung weighing about 1.02 to 1.04 kg with a TS level between 20 to 27% varied from 1009 to 1030 kg/m3. The static coefficient of friction of dung sample subjected to sun drying for five consecutive days was found to range between 0.69 and 0.81. The static coefficient of friction of dung sample dried about 20%, 30%, and 40% was 0.79, 0.73, and 0.712, respectively. The dynamic viscosity of the fresh cattle dung sample having different dung and water ratios as 1:1, 1:0.75, 1:0.50, 1:0.25, 1:0 was 184, 922, 1260, 3280, 5890 mPa·s, respectively.

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