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Cow dung an undeciphered boon: An overview

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Abstract
Current intensive agriculture system faces a major challenge to achieve higher production while supporting soil health and biodiversity. Among the livestock, cow has a prominent place in our country. For millennia, cow dung has been used for several purposes and served as a source of cheap fuel, housing material and insect repellent. *Panchgavya* that consisted of five ingredients from cow i.e. dung, urine, milk, curd and ghee is gaining attention of researchers for its various health benefits and its potential as therapeutic agent against many human diseases. Moreover, the cow dung possesses myriad batteries of microbes that exert their beneficial effects through production of metabolites. Since the ancient times, cow dung has also been used as an vital source of organic fertilizer and in the production of biogas. However, with modern civilization, this natural bioresource is forgotten and its exceptional qualities largely ignored. This review article is an attempt to gather all the scientific research findings that support the use of cow dung and its multifarious role in various sectors.

Keywords: Cow dung, bioresource, *Panchgavaya*, economy

Introduction
In India, total cattle population is 192.49 million (Livestock Census 2019) [1]. Cows constitute paramount resources for dairy and agriculture sectors in India. Aimed to increase the indigenous breed of cows 'Rashtriya Gokul Mission' was announced in 2014, by the Government of India. Kamdhenu or Indian cow (*Bos indicus*) is revered as sacred animal by Hindu (Kaushik *et al*. 2016) [18]. Cow dung is an inexpensive and economically viable option and is locally available in the rural areas of India (Randhawa and Kullar 2011) [38]. The dung coated mud walls and floor signifying its importance as a disinfectant and also provide insulation during summer and winter months. Even today, cow dung cakes are used as fuel in many rural areas. Since the ancient times, cow dung in India has been considered to be very sacred for religious ceremonies as well. For centuries, cow dung has served myriad purposes particularly in Indian rural households serving as a pivotal source of fuel, repelling mosquitoes, flies and as a sanitizer. Additionally, ashes of burnt cow dung are applied for cleaning kitchen utensils (Munshi *et al*. 2018) [27].

Cow dung is also serves as manure or agriculture fertilizer and escalates soil fertility significantly. Cow manure is a cheap and prime source of renewal energy in form of Biogas in future due to shortage of other non-renewal sources of energy like coal, oil and gases. Livestock waste composts along with minimum inorganic fertilizer as a soil amendment in low-input intensive farming are a viable agricultural practice to enhance soil fertility and productivity and to further lessen soil degradation (Das *et al*. 2017) [8]. With this background, it is evident that cow dung has been an indispensable and multifarious component in Indian domestic, agricultural and ayurvedic arenas since the time immemorial. This review is an attempt to develop an insight into various traditional and scientific role that is possessed by this un-deciphered bioresource.

Cow Dung: A unique cocktail of microflora
The reticulorumen in ruminants in the site where digestion of structural carbohydrates such as cellulose and hemicellulose can take place to any substantial degree through microbial fermentation. Microbes in the reticulorumen chiefly include bacteria, protozoa, fungi where bacteria and protozoa are harboured largely. From the perspective of a cow, a major benefit of having rumen is to provide a home to bacteria that possess the enzymes require to break the β1-4 linkage between the various sugars that make up cellulose and hemiceullose (Reece *et al*. 2015) [40].

The reticulo-rumen contains batteries of specialized anaerobic microbial populations responsible for the fiber breakdown, which is affected by biochemical and microbial characteristics of the rumen (Tesfaye and Hailu 2019) [49]. Lower part of the gut of the cow comprises of several microorganisms including *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactobacillus acidophilus*, *B. subtilis*, *Enterococcus diacetylactis*, *Bifido bacterium* and yeasts (commonly *Saccharomyces cerevisiae*) possessing probiotic activity (Ware *et al*. 1988) [54]. Since, livestock practices differ from one individual to another and from one geographical site to the other, eventually influences the microbial structure of manure released by the animals (Manyi-Loh *et al*. 2016) [22].

Cow dung is excreted by herbivore bovine animal species that consists of undigested residues of consumed matter which has passed through the cow's gastrointestinal system (Teo and Teoh 2011) [48] which is acted upon by ruminal microbes. Cow dung contains organic matter and fibrous material like cellulose, lignin and hemicellulose that has passed through the cow's digestive system (Rajeswari *et al*. 2016; Munshi *et al*. 2018) [37, 27]. Generally, cow dung is composed of about 80% water and supports a matrix of undigested plant material that is rich in nutrients, micro-organisms, and their byproducts (Sharma and Singh 2015) [41]. Cow dung is a mixture of dung and urine, usually in the ratio of 3:1 that encompasses crude fibre, crude protein, cellulose, hemicellulose and 24 types of minerals such as N, K, S, traces of P, Fe, Co, Mg, P, Cl, Mn, etc. (Nene 1999; Swain and Ray 2009) [28, 47]. Cow manure contains essential micro and macronutrients and considered as potential fertilizer for crop growth and it is an economic substitute for synthetic fertilizers (Kiyasudeen *et al*. 2015) [19]. Chomini *et al*. (2015) [7] demonstrated that digested cow dung had the highest percent increase for four major amino acids *viz* threonine, proline, glycine, alanine. Cow dung contains diverse microflora that comprises of about sixty bacterial species including *Bacillus* sp., *Corynebacterium* sp., *Lactobacillus* sp., few fungal sp., (*Aspergillus* and *Trichoderma*), about 100 species of protozoa and 2 yeasts (Bhatt and Maheshwari 2019) [6]. Teo and Teoh (2011) [48] recognised five distinct morphologically and physiologically bacterial isolates from cow dung where all the isolates produced protease, lipase and esterase lipase. In a study, Stevenson and Weimer (2002) [46] identified a strain as a member of the genus *Trichoderma* and designated strain A10, isolated from cow dung and that initially produced about 0.4 g ethanol l^{-1}.

Recently Rawat *et al.* (2019) [39] conducted a study on indigenous cows Sahiwal and reported a significantly higher population of microorganism in lactating cow dung as compare to heifer. In this study total bacterial population in heifer and lactating cow was found to be 16.17±0.7 and 20.16±1.58 cfu/g respectively. The yeast and fungi were (5.46±0.43 and 7.73±0.47cfu/g) respectively. In a study, Kiyasudeen *et al*. (2015) [19] collected three cow dung samples from three different farms with different feeding regime and reported that fresh cow dung samples are rich in microbial colonies. It was reported that total cfu/g of bacteria in CD2 (2.84±0.01x10 cfu/g) was significantly higher than CD3 (2.47±0.01x10 cfu/g) and CD1 (1.78±0.05x10 cfu/g) whereas total CFU/g of fungi in CD3 (2.78±0.01x10 cfu/g) was found to be substantially higher than CD2 (2.36±0.04 x10 cfu/g) and CD1 (2.14±0.01 x10 cfu/g). It was recommended to add nutrient rich supplements to the cows along with grass as major diet to obtain cow dung rich in nutrients. Girija and coworkers (2013) [12] made an attempt to probe the diversity of microbes present in cow dung using 16S rDNA sequencing approach and detected phyla such as Bacteroidetes, firmicutes and proteobacteria which efficiently degrade cellulose, chitin, lignin, xylan. Their findings also showed detection of *Acinetobacter*, *Bacillus*, *Stenotrophomona* and *Pseudomonas* species. Lately, Tomar *et al*. (2020) [51] attempted to isolate bacteria in cow dung using nutrient agar medium (NAM). In this study, they concluded that numerous species of gram positive bacteria were present in cow dung which included spore forming Bacillus spp., Enterococcus, Diploccocus and gram negative bacteria like - pseudomonas. Cow dung serves as a purifier of all wastes in the nature, is a rich source of microflora that can be utilized as probiotics, live microbial food supplements modifying the intestinal microbiota (Sharma and Singh 2015) [41].

Cow dung: An untapped eco-friendly bioresource

Energy is one of the foremost factors to global prosperity. With rising population, there is a steady increase in the global demand for energy. The scientific research for renewable sources of energy is essential owing to limited reserves for fossil and coal energy. Furthermore, the high dependency on fossil fuels as prime energy source has caused climate change, environmental pollution and degradation, hence leading to health problems in human (Aremu and Agarry 2012) [4]. The return-to-renewables will help to lessen climate change is an excellent way but it requires to be sustainable in order to ensure a sustainable future and bequeath future generations to meet their energy needs (Owusu and Asumadu-Sarkodie 2016) [31]. Using the process of anaerobic digestion, gases are derived from a wide range of organic wastes such as biomass waste, human waste, animal waste and used as source of energy (Putri *et al*. 2012) [33]. Biogas produced from renewable source can be one of the response for future energy production (Ambarsari *et al*. 2018) [3]. Biogas, is a mixture of diverse gases produced by anaerobic fermentation of organic matter from methanogenic bacteria (Sharma 2011; Gupta *et al*. 2016) [42, 15]. Biogas normally contains 50% and above methane (CH_4) and other gases in relatively low proportions namely, CO_2, H_2, N_2 and O_2 (Kalia *et al*. 2000) [16]. Cow dung is the main source of biogas or gobar gas production in India (Gupta *et al*. 2016) [15]. Cow dung as animal waste possess great potentials for generation of biogas and its use should be encouraged due to its early retention time and high volume of biogas yields (Ukpai and Nnabuchi 2012) [52].

Mixing of cow dung with manure obtained from other species has been investigated by many researchers. Previously, effect of mixing pig and cow dung on biogas yield was evaluated (Kasisira and Muyiiya 2009) [17]. The study showed that co-digestion of cow dung with pig manure increased biogas yield as compared to pure samples of either pig or cow dung. Rabiu *et al*. (2014) [34] studied the effect of cattle manure collected at different time inoculated with rumen fluid of cattle on biogas production at mesophilic condition. Their study revealed that if used between the ranges of 25–50% of rumen fluid, the best performance biogas production was observed. Furthermore, cattle manure collected after 12 h of defecation was recorded with the highest biogas production in comparison to 0 h and 24 h of cattle post-defecation. Similarly, in another study it was documented that cattle rumen fluids produces more biogas than the goats. It was further detailed that the increase in the biogas production at certain level was in respond to the amount of rumen fluids added into the mixture (Rabiu *et al*. 2014a) [35]. Poultry litter from broilers mixed with an optimum proportion of cow dung was found to be a substrate with a high potential for biogas generation by anaerobic digestion (Miah *et al*. 2016) [23].

With rising population, there is a tremendous pressure on agriculture to enhance food production to meet the demand. However, imprudent use of chemical fertilizers has led to the decline in soil fertility. Due to hike in prices of chemical fertilizer and their non-efficient role in long term sustainable production, the application of organic manure including cow dung is required for raising maximum productivity in sustainable way with better soil health. It is an effective tool to ameliorate physico-chemical and biological properties of the soil with higher yield of plants in sustained basis without altering the fertility of soil (Raj *et al*. 2014) [36]. Bacteria isolated from local breeds of different bovine animal have shown potential to be used as plant growth promoting bacteria (Aiysha and Latif 2019) [2]. Addition of cow dung enhances the organic carbon content of degraded soil that may further lead to the increasing activity of beneficial soil microbes as well as the fertility status of soil by increasing the availability of nutrients for the plants from soil (Zaman *et al*. 2017) [55]. Solomon *et al*. (2012) [45] compared the effects of organic manure and inorganic fertilizer (N.P.K.) on growth of Maize (*Zea Mays L*) and concluded that cow dung manure can be used in the absence of N.P.K. fertilizer. Zhang *et al*. (2020) [56] reported the suitability of cow manure fertilization for tea plantation and highlighted that application of cow manure can not only improve the variety of soil bacteria, but also effectively regulates the structure of soil bacterial community in tea plantation. In similar study, cow dung application have been found to be increased the total N, available P, exchangeable K, Ca, Mg, available S, Zn and B contents in soils and biomass yield of stevia (Zaman *et al*. 2017) [55].

Studies have suggested that exposure to the smoke of mosquito coils can pose significant acute and chronic health risks (Liu *et al*. 2003) [20]. Cow dung has been studied for it properties as mosquito repellent. Cow dung is a cheap, eco-friendly herbal repellent with long lasting protection that is safe for human and domestic animal skin with no side effect and no feedback of environmental ill effect, as a substitute to synthetic chemical repellents (Mandavgane *et al*., 2005; Mukherjee and Ghosh 2020) [21, 26]. Cow dung alone or in combination with other mosquito repellent plant species, could effectively used for the preparation of mosquito repellent products (Mukherjee and Ghosh 2020) [26].

Cow dung: a multifaceted biomass for bioremediation

In the last few decades, industrial revolution has caused an exceptional release of hazardous compounds into the environment, jeopardising the environmental balance of our planet (Godambe and Fulekar 2016) [13]. The presence of inorganic pollutants such as metal ions in the ecosystem pose a major environmental problem (Ojedokun *et al*. 2016) [29]. Bioremediation methods use naturally occurring microorganisms to detoxify man-made pollutants so that they change pollutants to harmless products that make soil fertile in the process (Randhawa and Kullar 2011) [38]. Cow dung ash is a bio-organic waste and absorbent and is an excellent water purifier. Entire harmful bacteria are killed just by adding a pinch or two of cow dung ash in few liters of water (Thakare *et al*. 2019) [50]. The adsorption abilities of cow dung by using aqueous solution of chromium has been investigated and it was concluded that adsorption highly depends on pH, time and initial concentration of chromium. Cow dung exhibited maximum adsorption at an acidic pH (Mohan and Gupta 2014) [25]. Few years back, Godambe and Fulekar (2016) [13] established a unique strategy for biodegradation of one of the most potent and widely accumulated hydrocarbons pollutant, benzene using indigenous source of cow dung. They documented that cow-dung harbour a range of microbes that show a great potential to degrade benzene. These bacteria in isolation or as a consortium utilize and multiply in presence of high benzene concentrations. Similarly, it has been reported that cow dung ash can be used for the removal of dyes from the waste water by adsorption (Sharma and Patel 2017) [43]. Similarly, bio-waste cow dung ash is an efficacious adsorbent in purifying biodiesel analogous to traditional water washing technology (Avinash and Murugesan 2017) [5]. Recently, Ojeme and coworkers (2019) [30] conducted batch experiments to investigate the removal of Pb(II) ions from aqueous solutions using chemically and thermally activated cow dung (CTAC) ash and non-chemically but thermally activated cow dung (NTAC) ash under various experimental conditions and reported cow dung as a potent absorbent as shown by its efficacy for Pb(II) ion removal.

Cow dung: A natural therapeutic gateway?

Cow dung has been referred to as a “gold mine” owing to its vast applications in the arena of agriculture, energy resource, environmental protection, and therapeutic applications (Randhawa and Kullar, 2011) [38]. The people frustrated from the heavy medication of allopathy are now using cowpathy drugs and being benefited by the *panchgavya* products for numerous diseases (Dhama *et al*. 2005) [10]. Previously, in a study it was documented that cow dung extracts exhibited partial antimicrobial property against human pathogens. Furthermore, the Indian cow dung extracts possess greater antimicrobial activity in comparison to other cow dung (Rajeswari *et al*. 2016) [37]. In a study, Mishra and coworkers (2014) [24] revealed that cow dung extract possess antimicrobial properties, that can be used to counter certain pathogenic diseases and other ailments. In another study, dung obtained from Indian cow exhibited superior antimicrobial activity compared to Jersey and Holstein cow dung. The extracts of the Indian cow dung showed antimicrobial activity against test organisms like *Klebsiella pneumonia* and *Escherichia coli* (Rajeswari *et al*., 2016) [37]. Interestingly, cow dung has been used as the economical substrate for the production of fibrinolytic enzyme (Vijayaraghavan *et al*. 2016) [53]. Cow dung is a home remedy used by many African communities to manage burn wounds and for its validation. Gololo *et al*. (2019) [14] suggested that the presence of proteases in cow dung could be one of the contributing factors towards its efficiency in managing traditional African burn wound. Cow dung has been documented to act as skin tonic and on mixing with crushed neem leaves and smeared on skin, it demonstrates good results for boils and heat rashes. Cow dung also used as tooth polish and relieves toothache (Kaushik *et al*. 2016) [18].

Traditionally, *Panchgavya* (Sanskrit for a blend of ‘five products from cow’) that consisted of five ingredients from cow i.e. dung, urine, milk, curd and ghee has shown numerous health benefits and possess many therapeutic properties against many ailments (Rajeswari *et al*. 2016) [37]. These five products are either used individually or in combination with other herbs, often referred to as *Cowpathy* or *Panchgavya Therapy* (Dhama *et al*. 2013) [9]. *Panchgavya* appears to be useful for the diseases such as cancer, acquired immunodeficiency syndrome (AIDS) and diabetes (Gupta *et al*. 2016) [15]. Paliwal *et al*. (2013) [32] determined the efficacy of Panchgavya on Spontaneous Motor Activity, muscle tone and pain on albino rats through administration of Panchgavya (50 mg/rat, orally) daily for 30 consecutive days. Their findings indicated a gradual increase in the muscle tone activity and analgesic activity in terms of reaction time.

Undoubtly, with these preliminary studies it is evident that cow dung can offer alternate low cost therapy having no side effects, however, there is a meagre scientific data to validate these claims and assertions before establishing efficacy of cow dung and its role as a prominent therapeutic agent. For this proper support and more in-depth probe should be undertaken by the scientists, researchers and clinicians/ physicians that will ultimately foster confidence in the public about its good virtues.

Estimates of production of dung

Dikshit and Birthali (2010) [11] estimated the total wet dung production (about 562 million tonnes) for the year 2003, out of which cattle contributed around 60% while buffalo contributed around 40% of total dung due to difference in the population share in total bovine. The evacuation rate of animal (average dung production/animal/day) mainly depends upon certain factors like quantity of feed intake, type of feed and physiological and environmental factors. It also varied among different species, age-groups and functional classification of bovines.

Table 1: Dung production by different categories of bovines, 2003

Categories	Evacuation rate (kg/day)	Population (million)	Dung production (million tonnes)	% Share in total dung produced
Cattle				
In-milk	6.63	35.80	86.63	25.78
Dry	6.58	22.30	53.56	15.94
Adult male	4.46	57.60	93.77	27.91
Young stock	4.43	63.10	102.03	30.37
Total		178.80	335.99	59.79
Buffalo				
In-milk	8.35	33.30	101.49	44.91
Dry	8.49	13.90	43.07	19.06
Adult male	6.65	6.70	16.26	7.20
Young stock	4.43	40.30	65.16	28.83
Total		94.20	225.99	40.21
Grand total		273.00	561.98	100.00

Source: Dikshit and Birthali (2010) [11].

If we arbitrary follow the value of evacuation rate as cited above and estimate the dung production for the year 2019, the production of dung as calculated would be about 629.91 million tonnes (Table 2).

Table 2: Dung production by different categories of bovines, 2019 with the help of evacuation rate suggested by Dikshit and Birthali in 2010

Categories	Evacuation rate (kg/day)	Population* (million)	Dung production (million tonnes)	% Share in total dung produced
Cattle				
In-milk	6.63	51.98	125.78	19.97
Dry	6.58	22.20	53.31	8.46
Adult male	4.46	47.40	77.16	12.25
Young stock	4.43*	70.91	114.66	18.20
Total		192.49	370.91	58.88
Buffalo				
In-milk	8.35	38.16	116.30	18.46
Dry	8.49	13.01	40.31	6.40
Adult male	6.65	9.28	22.52	3.58
Young stock	4.43	49.40	79.87	12.68
Total		109.85	259.00	41.12
Grand total		302.34	629.91	100.00

*Source: 20th livestock census for animal population as on 2019

Probable economy of dung

As the largest livestock population of the world, our country is also facing international scrutiny for its greenhouse gases emission. Therefore, some serious measures should be taken on the issue. We should try to convert our negative into positive. Dung can be utilized as the organic fertilizer instead of chemical fertilizers in the agricultural land. Setting up of biogas plant in the rural area for the prevention of fire wood usage in the domestic work can also reduce the problem of increasing pollution. Conversion of dung into the valuable products such as vermin-compost will not only add-up in the income of the farmer but also replacing it with chemical fertilizer will improve the soil fertility and will enrich the environment. The conversion rate of organic matter (75-80% moisture) into vermicompost is about 40-50 % (Sinha *et al.* 2010) [44]. If the total dung estimated could have been used for vermicomposting, we would had produced around 314.955 million tonnes of vermin-compost generating income (Rs.10/kg) of Rs. 3,149 billion/- (approx.).

Conclusion

Being largest total bovine population in world but reasonably low per animal productivity, only milk cannot be a way to improve economic status of small scale farmers. Dung has multifaceted properties that were largely ignored, can be a vital player in improving the income of the farmers in today's time. In the present work, scientific studies published in relation to the multiple usage of cow dung were reviewed and it can be concluded that owing to its rich microflora and many properties cow dung can serve through multiple ways and thus, it is a boon for sustainable livestock farming and can be viable alternative for non-renewable energy source.

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