**Cow Dung Based Economy: The Future Technological Prospects**

Bhawna Kalraa\*, Prayag Dutt Juyalb, Ashok Kumara

aFaculty of Agriculture, SGT University, Gurugram, Haryana 122505;

\*Email : [bk\_geny@yahoo.com](mailto:bk_geny@yahoo.com); Mobile:+91-8851014688

bMaya Group of Colleges, Dehradun, Uttarakhand 248011

**Abstract**

Cow dung and urine are readily available and reasonably priced renewable bio-resource. Indian farmers rely heavily on cattle’s and agriculture for their survival. Cow dung has traditionally been used as a fuel and mosquito repellent. To improve the economic situation of farmers, several items and technologies can be used with cow products. Vermi-compost, bio-fertilizers, and bio-pesticides, among other products that can be made from cow dung and urine, are all very important in agriculture. Cow dung contains variety of microorganism including *C. koseri, K. pneumonia, E. aerogenes*, *E. coli, K. oxytoca, Kluyvera* spp. and *M. morganii* which provides it antifungal, antimicrobial and anti-cancerous properties. In cowpathy, these microbiological characteristics can be used. Additionally, cow urine distillate functions as a bio-enhancer for a variety of medications. Cow dung can supply the nutrients and energy necessary for microbial growth, which results in the bioremediation of pollutants and the control of pollution. Cow urine is a highly effective bio-pesticide that along with neem oil. The future of the cow dung industry is in AI-based contemporary technologies, vermin-composting technology, biogas, compressed biogas, energy production, and smart automation technology for panchgavya production. Thus, farmers must be educated about the advantages of products made from cows apart from only dependency on milk in order to improve their economic situation.

**Keyword:** Cowdung, Bio-enhancer, Bio-pesticide, Bio-fertilizer,Vermi-compost, Panchgavya

**Introduction**

The cow has served as the basis of economy of Indian agriculture. Cow welfare coexists successfully with an agriculture-based economy. **Cow dung** commonly referred to as **cow pies** or **cow manure**. It is an animal byproduct from the bovine family. The undigested remnant of plant materials that has passed through the animal's digestive system is known as cow dung. It is an affordable and accessible bio-resource. It is a blend of cellulose, lignin, and hemicelluloses. It has minerals like sulfur, nitrogen, potassium, iron, magnesium, copper, cobalt, and manganese. Indian villagers utilize cow dung as fuel and plaster the floors and walls of their homes to insulate them in the winter and summer. Cow dung is utilized in agriculture in India as manure, bio-fertilizer, bio-pesticide, pest repellant, and a source of energy (Gupta et al 2016). Through phosphate solubilization cow dung microbes have demonstrated a natural ability to boost soil fertility. In comparison to indigenous Indian cows, the native Indian cow also contains higher amounts of calcium, phosphorus, zinc, and copper (Garg and Mudgal 2007; Randhawa and Kullar 2011). Numerous microbes, including *C. koseri, K. pneumonia, E. aerogenes*, *E. coli, K. oxytoca, Kluyvera* spp. and *M. morganii*, are found in cow manure (Gupta et al 2016; Randhawa and Kullar 2011). These microorganisms from cow manure are utilized to regulate environmental contaminants and energy production. Apart from that cow products are used for agriculture, pesticides, cosmetics and floor cleaner.

**Important technological advancements and products through cow dung and cow urine (Figure 1):**

1. **Model based on machine learning and Artificial Intelligence (AI)**: AI-based model was created to assist donors track their contributions for non-milching. By incorporating stray cows in a circular economy, it offered a solution of stray cows in real-time. It uses machine learning-aided facial recognition technology.When cow stop milking, cow owners typically abandon non-milching cows. These cows get injured, have accidents, and subsist on trash. By using AI-based technology, the donor can provide and track their donations as well as stray animal byproducts such as cakes, compost, incense sticks, and other derivatives of cow dung. Additionally, cow urine and cow dung can be used to create biogas and biofertilizer generation facilities for additional financial gain (Kedia et al 2022).
2. **Vermi-composting technology:** Vermi-composting is reorganized as an environmentally beneficial process for [bioconversion](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioconversion) of organic solid wastes produced by agricultural, industry, rural and urban areas that are acting as a reservoir for environmental pollutants. It is made from the residue left over from the distillation process from biogas as well as mixture of herbs and urine. Poring the mixture into composting pits after mixing with cow urine results in superior quality vermi-compost with increased essential micronutrients. Cattle dung is essential for mineralization, nutrient recovery, earthworm and microbial activity and the creation of vermin-fertilizer in the vermin-composting of organic wastes. The earthworm excretory pellets known as "vermicasts" can improve soil health and control the soil's texture (Yuvaraj et al 2021).
3. **Direct Combustion Technologies:** In India cow dung is used as a fuel source. Animal manure is thermally utilized on a big scale in India, where it is regarded as the primary fuel in the production of power in a biogas plant (Alfa et al 2014; Zahid et al 2017). The use of biomass as a sustainable energy source has recently grown on a global scale. Agricultural waste such as cow dung is being used for purpose. Pellets made from cow dung were tested as a possible renewable energy source. Cow dung pellets can be used as potential source of renewable energy. Biomass could be the foundation of the energy sector of the future and various researches presented a idea of using cow dung pellets as a potential source of renewable energy that is accessible everywhere (Alfa et al 2014; Zahid and Surindra 2017; Szymajda et al 2021).
4. **Bioremediation:** According to various studies, cow dung contains a diverse bacteria that are ideal for the microbial degradation of pollutants including *Acinetobacter*, *Bacillus*,  *Pseudomonas*, *Serratia* and *Alcaligenes* spp.(Adams et al 2014;Gupta et al 2016; Randhawa and Kullar 2011). According to recent study the natural capacity of cow dung microflora to break down hydrocarbons in engine oil-contaminated soil, the total petroleum hydrocarbon reduced up to 81% by the metabolic activities of cow dung microorganisms. Another study suggested using cow dung in the right dosage could be quite effective at causing water contaminated with motor oil to biodegrade (Umanu et al [2013](https://bioresourcesbioprocessing.springeropen.com/articles/10.1186/s40643-016-0105-9#ref-CR146)). A metabolic mechanism for the microbial breakdown of polycyclic aromatic hydrocarbons has also been proposed. Cow dung can provide the nutrients and energy needed for microbial development, which leads to the bioremediation of contaminants. In addition to being able to break down lignocelluloses in vitro, *C. stercoreus*, which was isolated from cow dung. It is also capable of breaking down the antibiotic enrofloxacin (Randhawa and Kullar 2011).

**Figure 1. Cow based economy and technical aspects**

1. **Bio-pesticide:** Similar to neem leaves, cow urine is an excellent bio-pesticide. Such bio-pesticides can be used safely, and even their residues don't stay in the food chain for very long. It lacks the negative consequences of chemical insecticides. Neem leaves weigh about 2 kg and are soaked in 10 liters of cow urine with various other veggies. Additionally, a 1:50 ratio may be utilized for spraying. Mixture of cow dung and cow urine is excellent manure and natural insecticide. The mixture made from neem leaves and cow urine is excellent pesticide and promotes plant development (Dhama et al 2005a; Randhawa and Kullar 2011)
2. **Electricity Generation:** Microbial Fuel Cells transform biodegradable materials into power by using microorganisms as a biocatalyst. Natural cow dung produces more open circuit voltage than sterile cow dung. For this electrogenic properties of five bacteria’s were studied (Shiv K et al 2012). It was concluded from the whole work that microbial fuel cell has ability to utilize microbes from cow dung for power generation and presents cleaner technology (Siddique et al 2018).
3. **Cow dung houses with antibacterial properties**: Cow dung is best natural disinfectant cow dung it has anti-bacterial properties. It is not unusual to discover a house's entire floor covered in some fresh cow dung paste in any typical Indian village plasters are commonly found in many Indian homes. *Mycobacterium vacca-*a common bacteria found in cow dung. It stimulates neurons in the brain that make serotonin, a neurotransmitter involved in emotions of well-being and happiness ([Malan-Muller](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077) S et al 2018).
4. **Smart Automation for Production of Panchagavya.** A unit was created for the production of panchagavya through automated system. It includes an automated mechanism for producing panchagavya. In these system sensors for pH, moisture, temperature, and pressure were integrated. The system uses an ATmega 328 microcontroller to automate the entire process ([Sumathi](https://sciprofiles.com/profile/2496139) and [Mohamed-Abdullah J](https://sciprofiles.com/profile/author/aFFlbzJlNE1Jc0JOYitXL2hWNW9WNjdaK1hnK2dpZ1ZWdEE5RG04d0drSnl0ZUR5WndaelhERXhpeVhKUFBpRQ==) 2022).
5. **Mosquito Repellent based village economy:** Chemical mosquito repellents include hazardous substances that are bad for human health. Herbal mosquito repellents made from cow dung are based on Indian traditional methods. They have relatively low production costs as well. Due to its herbal properties, it does not lead to any respiratory problems when inhaled. Numerous studies have attempted to maximize the therapeutic properties. According to Indian philosophy, cow excrement is extremely sacred since it is believed to be the home of the Goddess of Wealth, *Gomay Vaste Laxmi*. Through the production of this product, youth can generate employment, and farmers can be benefited financially (Dhama et al 2005a; Sharma et al 2017).
6. **Green Fertilizer made from cow dung could transform big agriculture:** Cow dung which is dark brown in color is one of the best known natural Agriculture fertilizer or organic manure. It has tremendous importance in Indian cultures. Manure is known in many Indian languages “govar” ‘Go” meaning Cow and “Var” meaning boon. According to Indian vedic system, food that we eat is interconnected with our physical being as well as mental consciousness. Organic farming is one the key activities. Therefore, purity of food determines the wellbeing of the society. Application of cow dung for soil enrichment is age old agriculture practice in India which lost its importance post introduction of chemical fertilizers. But with rising demand of chemical free food in recent years and growing acceptance of organic farming, cow dung form a very important link in chemical free farming. Cow dung cakes is an excellent fertilizer with N:P:K and organic manure used for all type of plants (Gupta et 2016).
7. **As fuel**: In rural places, cow dung is utilized as fuel. Compared to electric ovens, it is still regarded as an excellent fuel for baking potatoes. As per tradition temperature caused by the combustion of cow dung gas only rises to a certain point, keeping the food's nutrients from degrading. Its smoke also kills hazardous microorganisms of the air at the same time. In many parts of India and other developing countries, in mountain regions and villages dried cow dung cake is used as a fuel. It is also dried into cake like shapes called **Upla** or **Kanda** and used as replacement for firewood for cooking in **chulah**.
8. **Bio-enhancer:** Bio-enhancing is one of its many properties of cow urine. Distilled cow urine is commonly used as an alternative to anti-bacterial and anti-cancer medicine. Cow urine mixture with antibiotics is used in the prevention of microorganisms. CSIR Indian scientists are working on various medicinal properties of cow urine and other panchgavya products in different laboratories. They are making efforts for various types of prevention and treatments in the field of medical department in the form of Panchgavya products. As a bioenhancer, cow urine distillate is more effective than cow urine and increases the effectiveness of antimicrobial, antifungal and anticancer medications. Additionally, it makes zinc and the bovine serum albumin-conjugated gonadotropin-releasing hormone more active. Rifampicin, an antibiotic used to treat tuberculosis, can be bio-enhanced by cow urine. Additionally, the transfer of antibiotics, tetracycline, and ampicillin is improved by cow urine distillate([Randhawa](https://pubmed.ncbi.nlm.nih.gov/?term=Randhawa%20GK%5BAuthor%5D) GK 2010).
9. **Biogas:** Due to rising human needs, non-renewable energy sources like coal, oil, and gases are rapidly running out. Methane, which is produced by animal waste to a degree of 55–65%, has a global warming effect on the earth that is 21 times greater than that of carbon dioxide. The organisms involved in the creation of biogas are referred to as methanogens, hydrolysers, and acetogens. The hydrolytic stage of the synthesis of biogas involves extracellular hydrolytic enzymes, particularly cellulase, xylanase, amylase, protease, and lipase, which are excreted by bacteria. Methane (50–65%) and CO2 (25–45%) make up the majority of biogas, a mixture of various gases created by anaerobic fermentation of organic matter from methanogenic bacteria. The production of biogas during the winter months in hilly places is reduced by 70% because mesophilic bacteria cannot survive in psychrophilic temperature ranges (Gupta et al 2016). Bio gas is used to power internal combustion engines. Cow dung remnants from the engine can be utilized to make manure that is great fertilizer for crops (Rui et al 2018).

**Table 1: Bacteria’s and temperature range for biogas production.**

|  |  |
| --- | --- |
| Bacteria’s | *Pseudomonas* sp., *Azotobacter* sp, Purple sulphur or purplenon-sulphur bacteria, *E. coli, Bacillus* sp., *Pseudomonas* sp., *Staphylococcus* sp. and *Proteus* sp. |
| Temperature Range | Mesophilic (32–38 °C)  Thermophilic (50–55 °C) |

1. **Compressed Bio-gas:** In India, compressed biogas will be particularly useful for need of large population and small land area. Lots of organic trash is generated in India. We can avoid putting this material in landfills if we use it to generate electricity. Biogas processing technology has already been developed in India. Using cutting-edge technology, compressed biogas can match the performance of compressed natural gas. Methane makes up 60% of biogas, and CO2 makes up 40%. This is equivalent to the CNG's pure composition following processing. Power plants and automobiles may both run on this compressed biogas.
2. **Health management of humans:** Cow dung has antibacterial and disease-preventing qualities. The bacterium that causes sickness and putrefaction is eliminated by it.
3. **Panchgavya**: It is an ayurvedic cure consists of five (pancha) cow products (gavya)-milk, curd, ghee, dung and urine. It can be used to make a variety of herbal medications and is thought to be able to treat a wide range of diseases (Pathak and Kumar [2003](https://bioresourcesbioprocessing.springeropen.com/articles/10.1186/s40643-016-0105-9#ref-CR112); Jarald et al [2008](https://bioresourcesbioprocessing.springeropen.com/articles/10.1186/s40643-016-0105-9#ref-CR67)).In Ayurveda, Panchagavya is especially significant. It has medicinal properties that combat a number of illnesses and conditions. To this, mixtures of several herb varieties may be added. Like other medical systems like homeopathy and allopathy, this one is called “cowpathy”. According to Ayurveda, utilizing Panchgavya can treat both physical and mental disorders.It is effective in treating a wide range of illnesses, including the flu, allergies, colds, cough, asthma, gastrointestinal tract disorders, ulcer, wound healing, heart diseases, skin infections, tuberculosis, chickenpox, hepatitis, leprosy, and numerous other bacterial and viral infections. (Dhama et al 2005b; Jain et al 2010). Utilizing Panchagavya regularly helps the body rid itself of harmful toxins. Additionally, panchgavya's effect on the central nervous system's ability to regulate pain, muscular tone, and spontaneous motor activity has been established in albino rats (Paliwal et al 2013). Panchgavya-derived products make great organic fertilizers, manures, biogas, fuel, and biopesticides, among other things.
4. **Cowpathy:** Ayurvedic ingredients derived from indigenous cows are the basis of the treatment known as "cowpathy." According to the ancient Ayurvedic literature (Vir Charak Samhita, Sushrut Samhita, and Gad Nigrah), prime products from indigenous cows have a variety of pharmacological uses, including the treatment of leucoderma, hyperlipidemia, arthritis, gastrointestinal tract disorders, acidity, diarrhoea, dysentery, cancer, diabetes, blood pressure, asthma (Dhama et al 2013; Bajaj et al 2022). Many Ayurvedic practitioners use cow urine for treatments. However, much of the scientific information is lacking in this regards, due to batch to batch fluctuation, seasonal changes, urine collection time and its effect, the impact of feed, and differences/similarities between the urine of other cattle (Bajaj et al 2022).
5. **Anti fungal properties:** According to some studies, cow dung contains an antifungal component that prevents the growth of coprophilous fungi (Dhama et al [2013](https://bioresourcesbioprocessing.springeropen.com/articles/10.1186/s40643-016-0105-9#ref-CR35)). In cow dung *Eupenicillium* *bovifimosum* creates chemicals that resemble patulodine and have strong antigungal properties (Lehr et al. [2006](https://bioresourcesbioprocessing.springeropen.com/articles/10.1186/s40643-016-0105-9#ref-CR86)). Cow dung microorganisms K4 have antibacterial activity against *E. coli* (Teo and Teoh 2011). When mice were given with live *M. vaccae*, its effects on anxiety and learning capacity were also evaluated, and it produced positive results (Matthews and Jenks 2013). According to these researches, cow dung may be a valuable source of microorganisms that could potentially lead to new antibacterial compounds.
6. **Cow urine therapy:** The medical benefits of cow urine, including its antibacterial, antifungal, and anticarcinogenic qualities. Cow urine increases tolerance against the mcf-7 human body cancer cell line (Gupta et al 2016). There are 24 different salts in cow urine, which is used to treat numerous illnesses. 95% of cow urine is water, 2.5% is urea, 2.5% is minerals, harmones, and enzymes. Iron, calcium, phosphorus, salts, carbonic acids, potash, nitrogen, ammonia, manganese, sulphur, phosphate, potassium, urea, amino acids, enzymes, cytokines, and lactose are all present in it. Amino acids and cytokines present in cow urine boost immunity. Drug-resistant bacteria, viruses, and illnesses like cancer are all killed by cow urine. It is beneficial for treating conditions including the flu, sinusitis, allergies, arthritis, snake bites, chicken pox, constipation, fever, obesity, baldness, edema, hepatitis, leprosy, gastric ulcers, burning, fatigue, fever, and Parkinson's illnesses (Gupta et al 2016).

**The description of Panchagavya is as follows:**

1. **Milk:** Cow milk, according to Ayurveda, offers nourishment that cannot be found in any other food. Cow's milk, which is one of the essential nutrients to strengthen ojas—the vital energy that controls our immunity, vigor, and happiness—nourishes all bodily functions after being correctly digested. The good-fat milk produced by Indian Cow A-2 contains -casein protein, which supports the nervous and gastrointestinal systems. This milk is the reverse of the Jersey cow's A-1 milk. When compared to buffalo milk, it has fewer calories, lower cholesterol, and higher levels of micronutrients like vitamin. It also contains more moisture, carotene, thiamine, vitamin C, riboflavin, sodium, and potassium.
2. **Curd:** The byproduct of cow's milk is curd. All of the top Ayurvedic doctors, including Charaka and Susukhata, have written about the advantages and qualities of curd. Curd can treat a variety of illnesses. It is regarded as a tonic and protects against early aging. Patients who suffer from diarrhoea and nausea can get relief from curd, and it is also helpful for chronic gastric and particular colitis. Cow's milk curd is regarded as an anti-inflammatory and blood cleanser. It helps with gall diseases and blood-related issues if taken with sugar. In gastrointestinal issues, it is helpful. Since ancient times, curd has been combined with cumin, black salt, and sugar. Whey butter has a very little amount of milk fat.
3. **Ghee:** Cow ghee enhances mental wellness, and resistance to infection. It has cholesterol-lowering and immune-stimulating properties. Cow ghee improves memory function. Cow ghee enhances digestion and benefits vision. It delays the onset of old age. You can make a micronutrient supplement by combining non-fat cow's milk, vitamins, honey, and cow's ghee.

**Conclusion and current prospective**

Cows are mostly raised in India for milk production due to the economic benefits to farmers.Non-milching cows are not economic beneficial to farmers. Generally, these cows are sold to slaughterhouses or abandoned as strays. Because of their low literacy, most farmers are unaware of the benefits of cow urine and manure. It is necessary to protect cattle’s as an effort is being made through AI-Based technology. Cow dung also pollutes roadways and grounds. Very large amount of urine (5-6liters) and cow dung (8-10kg) is produced per cow on an average. The benefits of cow’s product should be known to the farmers. Farmers believe that cow dung and urine are sources of pollution and of no use but most of them are unaware it can be used as bio-pesticides, bio-fertilizers, and panchgavya. From cow dung electricity and biogas can be produced. Electricity may be made from cow manure. Due to its numerous applications in the fields of agriculture, energy resources, environmental protection, and medicine, cow dung is regarded as a gold mine. Cow dung functions as an antibiotic, fungicide, and antiseptic must be utilized in cowpathy. After composting, cow dung contains a lot of nitrogen. Insects found in plants also perish when exposed to cow manure and cow urine. Therefore, the usage of cow-based products is where the future of India's agricultural economy lies.

**References**

* **Adams GO, Tawari-Fufeyin P, Ehinomen I (2014)** Laboratory scale bioremediation of soils from automobile mechanic workshops using cow dung. J Appl Environ Microbiol 2:128–134.
* **Alfa IM, Dahunsi SO, Iorhemen OT, Okafor CC, Ajayi SA (2014**) Comparative evaluation of biogas production from Poultry droppings, Cow dung and Lemongrass. Bioresour. Technol. 157, 270–277.
* [**Bajaj**](https://pubmed.ncbi.nlm.nih.gov/?term=Bajaj%20KK%5BAuthor%5D) **KK,**[**Chavhan**](https://pubmed.ncbi.nlm.nih.gov/?term=Chavhan%20V%5BAuthor%5D) **V,**[**Nishikant A, Raut**](https://pubmed.ncbi.nlm.nih.gov/?term=Raut%20NA%5BAuthor%5D)**,** [**Gurav**](https://pubmed.ncbi.nlm.nih.gov/?term=Gurav%20S%5BAuthor%5D) **S(2022)** Panchgavya: A precious gift to humankind [J Ayurveda Integr Med.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8814384/) 2022 13(2): 100525.
* **Dhama K, Chakraborty S, Tiwari R (2013)** Panchgavya therapy (Cowpathy) in safeguarding health of animals and humans—a review. Res Opin Anim Vet Sci 3:170–178.
* **Dhama K, Rathore R, Chauhan RS, Tomar S (2005a)**. Panchgavya (cowpathy): an overview. Int J Cow Sci.1:1–15.
* **Dhama K, Chauhan RS, Singhal L (2005b)** Anti-cancer activity of cow urine: current status and future directions. Int J Cow Sci 1:1–25.
* **Garg AK, Mudgal V (2007)** Organic and mineral composition of Gomeya (cow dung) from Desi and crossbred cows—a comparative study. Int J Cow Sci 3:1–2
* **Gupta KK, Aneja KR and Rana D (2016)** Current status of cow dung as a bioresource for sustainable development. Bioresources and Bioprocessing. 3:28
* **Jain NK, Gupta VB, Garg R, Silawat N (2010)** Efficacy of cow urine therapy on various cancer patients in Mandsaur District, India—a survey. Int J Green Pharm 4:29–35
* **Jarald E, Edwin S, Tiwari V, Garg R, Toppo E (2008)** Antioxidant and antimicrobial activities of cow urine. Global J Pharmacol 2:20–22.
* **Kedia, Kumar G, Garg A, Mishra, Kumar P, Krishna, Nishant, Mishra, Aprajita, (2022).** "[Gai Aadharit Unnati (GAU): Modernizing Cow based Economy through Application of Advanced Technology](https://ideas.repec.org/p/iim/iimawp/14675.html)," [IIMA Working Papers](https://ideas.repec.org/s/iim/iimawp.html) WP, IIM Ahmedabad, Research and Publication Department
* **Lehr NA, Meffert A, Antelo L, Sterner O, Anke H, Weber RWS (2006)** Antiamoebins, myrocin B and the basis of antifungal biosis in the coprophilous fungus *Stilbella erythrocephala*. FEMS Microbiol Ecol 55:105–112
* [**Malan-Muller**](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077) **S,** [**Valles-Colomer**](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077) **M,** [**Raes**](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077) **J,** [**Christopher A, Lowry**](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077)**,** [**Seedat**](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077) **S,** [**Sian MJ Hemmings**](https://www.liebertpub.com/doi/full/10.1089/omi.2017.0077) **(2018)** The Gut Microbiome and Mental Health: Implications for Anxiety- and Trauma-Related Disorders [OMICS: A Journal of Integrative Biology](https://www.liebertpub.com/journal/omi)[22- 2](https://www.liebertpub.com/toc/omi/22/2)
* **Matthews DM, Jenks SM (2013)** Ingestion of *Mycobacterium vaccae* decreases anxiety-related behavior and improves learning in mice. Behav Process 96:27–35.
* **Paliwal R, Sahni YP, Singh SK, Sen S (2013)** Effect of panchgavya on central actions in albino rats. Pharma Sci Monit 4:3940–3946
* **Pathak ML, Kumar A (2003)** Cow praising and importance of Panchyagavya as medicine. Sachitra Ayurveda 5:56–59
* [**Randhawa**](https://pubmed.ncbi.nlm.nih.gov/?term=Randhawa%20GK%5BAuthor%5D) **GK(2010).** Cow urine distillate as bioenhancer. [J Ayurveda Integr Med.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3117312/) 1(4): 240–241.
* **Randhawa GK, Kullar JS (2011)** Bioremediation of pharmaceuticals, pesticides, and petrochemicals with gomeya/cow dung. ISRN Pharmacol. 362459. doi:[10.5402/2011/362459](https://doi.org/10.5402/2011/362459)
* **Rui, D,  San D, Migue B, CoronB, GaiterA, DomíngueA** **(2018)** Environmental and economic analysis of power generation in a thermophilic biogas plant. [Science of The Total Environment](https://www.sciencedirect.com/journal/science-of-the-total-environment).  [633](https://www.sciencedirect.com/journal/science-of-the-total-environment/vol/633/suppl/C), 15 (1418-1428).
* [**Sharma**](https://www.researchgate.net/scientific-contributions/Kranti-Sharma-2129035143?_sg%5B0%5D=ppzgcx_baiZ-ofwO8_T6UyBGYhgdaEuShOhcpkuMgJsjpvDPaS269pM1HZY-fu40GHaogxw.l81vyMRrnuujdaBSw0VWWiZFSD68y2IWEzt4a3PcAK3h11_4omsopoJGYVX_w0NGJP_sQ1q8gtSJdsgjtW4Jlg&_sg%5B1%5D=DsL4MTbhRBoaPnyHg2O5x6JBWCo1j0jiR-q3wpO7ad5HqlF-zhwtIefoxc0q98dl8eGVz0g.11KXSneGc7mjEVFjgNGGLk-wi4jHmzgCjiN488t70QWYhDzEMkEAZJ7rfbKl7kGLVz41LpHvdQN-rLXT4n88bA) **K,** [**Mishra**](https://www.researchgate.net/scientific-contributions/Sharad-Mishra-2064864384?_sg%5B0%5D=ppzgcx_baiZ-ofwO8_T6UyBGYhgdaEuShOhcpkuMgJsjpvDPaS269pM1HZY-fu40GHaogxw.l81vyMRrnuujdaBSw0VWWiZFSD68y2IWEzt4a3PcAK3h11_4omsopoJGYVX_w0NGJP_sQ1q8gtSJdsgjtW4Jlg&_sg%5B1%5D=DsL4MTbhRBoaPnyHg2O5x6JBWCo1j0jiR-q3wpO7ad5HqlF-zhwtIefoxc0q98dl8eGVz0g.11KXSneGc7mjEVFjgNGGLk-wi4jHmzgCjiN488t70QWYhDzEMkEAZJ7rfbKl7kGLVz41LpHvdQN-rLXT4n88bA) [**S, Ashutosh Dubey Dubey**](https://www.researchgate.net/profile/Ashutosh-Dubey-18?_sg%5B0%5D=ppzgcx_baiZ-ofwO8_T6UyBGYhgdaEuShOhcpkuMgJsjpvDPaS269pM1HZY-fu40GHaogxw.l81vyMRrnuujdaBSw0VWWiZFSD68y2IWEzt4a3PcAK3h11_4omsopoJGYVX_w0NGJP_sQ1q8gtSJdsgjtW4Jlg&_sg%5B1%5D=DsL4MTbhRBoaPnyHg2O5x6JBWCo1j0jiR-q3wpO7ad5HqlF-zhwtIefoxc0q98dl8eGVz0g.11KXSneGc7mjEVFjgNGGLk-wi4jHmzgCjiN488t70QWYhDzEMkEAZJ7rfbKl7kGLVz41LpHvdQN-rLXT4n88bA)**(2017).** Development of Cow Dung Based Herbal Mosquito Repellent. [Journal of Krishi Vigyan](https://www.researchgate.net/journal/Journal-of-Krishi-Vigyan-2349-4433) 6(1):50
* **Shiv K, Kumar, Dev H, Babu G(2012)** A study on the electricity generation from the cow dung using microbial fuel cell. Journal of Biochemical Technology. 3(4), 442-447.
* **Siddique M, Mengal AN, Soomro SA, Aziz S, Khan MN, Mushtaq F, Khan, G, Jatoi AS and Khan A (2018).** Development of laboratory scale microbial fuel cell for electricity generation from cow dung manure using microbes, J Applied and Emerging Sciences, 8, 102–107
* [**Sumathi V**](https://sciprofiles.com/profile/2496139), [**Mohamed Abdullah J**](https://sciprofiles.com/profile/author/aFFlbzJlNE1Jc0JOYitXL2hWNW9WNjdaK1hnK2dpZ1ZWdEE5RG04d0drSnl0ZUR5WndaelhERXhpeVhKUFBpRQ==) **(2022)** Smart Automation for Production of Panchagavya Natural Fertilizer Agronomy12(12), 3044
* [**Szymajda**](https://sciprofiles.com/profile/743648) **A,** [**Łaska**](https://sciprofiles.com/profile/746842) **G and**  [**Joka**](https://sciprofiles.com/profile/754306) **M (2021)** Assessment of Cow Dung Pellets as a Renewable Solid Fuel in Direct Combustion Technologies Energies14(4), 1192.
* **Teo KC, Teoh SM (2011)** Preliminary biological screening of microbes isolated from cow dung in Kampar. Afr J Biotechnol 10:1640–1645
* **Umanu G, Nwachukwu SCU, Olasode OK (2013)** Effects of cow dung on microbial degradation of motor oil in lagoon water. GJBB 2:542–548
* **Yuvaraj, Thangaraj R, Ravindran B, Chang SW, Karmegam N (2021).** Centrality of cattle solid wastes in vermicomposting technology- A cleaner resource recovery and biowaste recycling option for agricultural and environmental sustainability. [Environmental Pollution](https://www.sciencedirect.com/journal/environmental-pollution) [268, Part A](https://www.sciencedirect.com/journal/environmental-pollution/vol/268/part/PA), 115688.
* **Zahid, GR, Surindra S (2017).** Anaerobic digestion of activated sludge, anaerobic granular sludge and cow dung with food waste for enhanced methane production. J. Clean. Prod.  164, 557–566.