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Importance of Indigenous Cow Dung and its Microbiota

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A B S T R A C T

Indigenous cows have a high potential for organic manure, which is required for organic farming, and in the near future, and will be the backbone of organic farming and India's agricultural economy. It increases plant resistance to pests and diseases, encourages plant growth, and promotes other beneficial activities such as sulphur oxidation and phosphorous solubilization. *Lactobacillus plantarum, Lactobacillus casei, Lactobacillus acidophilus, B. subtilis, Enterococcus diacetylactis, Bifidobacterium, and yeasts* (commonly *Saccharomyces cerevisiae*) are found in the lower part of the cow's gut. Cow dung contains beneficial microflora, including *bacilli, lactobacilli, cocci*, and a wide range of known and unknown fungi and yeast. Under NABARD sponsored organic farming project executed by ARF, it was observed that vermicompost made out of cowdung improves the texture, water holding capacity, organic carbon content and microbiota of soil for enhanced productivity per acre of land. This review highlights the significance of indigenous cow dung and its microbes in agriculture, industry, pharmaceuticals, and environment.

Introduction

Cows were historically held in high regard in India. They gave people a sense of pride and social standing. The larger a person's cow herd, the more powerful they are. But now everything has changed. Cows are treated similarly to any other milk-producing animal. These animals are also valued because they produce milk. The value of the cow decreases as the level of milk production decreases with lactation/aging, and when milk production falls below the owner's expectations, the cow is disposed of. Cows of various breeds are more valuable and preferred because they produce more milk. Because exotic breeds like Holstein Friesian, Jersey, and Brown Swiss produce more milk than indigenous breeds, they are given preference over indigenous breeds. As a result, our well-established indigenous breeds and these exotic breeds have selectively crossed. Indian cattle breeds, on the other hand, are well known for their endurance and disease resistance, such as the Gujrat native breed shown in fig 1, which is resistant to tick infestation and mastitis. Similarly, Indian breeds of cows are tougher and more adaptable to various types of stresses. Thus, cows have a high potential for organic manure, which is required for organic farming, and these indigenous cows will be the backbone of organic farming and the agricultural economy in India in the near future (Anil Kumar Garg and Vishal Mudgal, 2007).

Increasing output while preserving soil health and biodiversity is a significant challenge in today's intensive agriculture system. Our country's most important livestock is the cow (Mishra *et al.,* 2020). The total livestock population in the country is 536.76 million, with rural and urban livestock populations of 514.11 million and 22.65 million, respectively, according to the 20th Livestock Census. The total number of cattle in the country in 2019 is 193.46 million. The country's Exotic/Crossbred and Indigenous/Non-descript Cattle populations are 51.36 million and 142.11 million, respectively, according to the survey (Viji, 2022). Livestock are vital resources for India's dairy and agriculture industries (Mishra *et al.,* 2020). In India, cows are the most common cattle and produce 9-15 kg of dung per day, accounting for 69.9% of the population (Kartikey Kumar Gupta *et al.,* 2016). For millennia, cow dung has been used for a variety of purposes, including cheap fuel, building material, and insect repellent. Since ancient times, cow dung has also been used as an important source of organic fertilizer and in the production of biogas (Mishra *et al.,* 2020). It boosts plant resistance to pests and diseases, promotes plant growth, and encourages other beneficial activities like sulphur oxidation and phosphorous solubilization (Saurab kishore munshi *et al.,* 2018). This natural bioresource, however, has been forgotten by modern civilization, and its exceptional qualities have been forgotten.

Cow dung is the undigested excrement of herbivorous bovine animal species' consumed food material, primarily lignin, cellulose, and hemicelluloses. Cow dung contains nitrogen, potassium, trace amounts of sulphur, iron, magnesium, copper, cobalt, and manganese (Saurab kishore munshi *et al.,* 2018; Sudhanshu S. Behera and Ramesh C. Ray, 2021). In ruminants, the reticulorumen is where structural carbohydrates such as cellulose and hemicellulose can be digested to a significant extent through microbial fermentation. The most common microbes in the reticulorumen are bacteria, protozoa, and fungi, with bacteria and protozoa being the most abundant. Rumen provides an environment for bacteria which contain the enzymes needed to break the 1-4 linkage between the various sugars that comprise cellulose and hemicellulose. The lower part of the cow's gut contains probiotic microorganisms such as *Lactobacillus plantarum, Lactobacillus casei, Lactobacillus acidophilus, B. subtilis, Enterococcus diacetylactis, Bifidobacterium,* and yeasts (commonly *Saccharomyces cerevisiae*) (Ayush Tomar, 2020; Mishra *et al.,* 2020).

According to Vedic scriptures, Gomeya/Cow dung is not a waste product but rather purifies all waste in nature (Kalpana Bhatt and Dinesh Kumar Maheshwari, 2019; Kartikey kumar gupta *et al.,* 2016). Cow dung microflora contains approximately 60 bacterial species, with *Bacillus sp., Corynebacterium sp., Lactobacillus sp.,* a few fungal species *(Aspergillus and Trichoderma*), approximately 100 protozoa species, and two yeasts dominating. According to research, it contains a diverse group of bacteria such as *Acinetobacter, Serratia,* and *Alcaligenes spp.,* as well as plant growth promoting bacteria (Kalpana Bhatt and Dinesh Kumar Maheshwari, 2019). In 2019, a study in Haridwar and Dehradun, Uttarakhand, isolated 70 bacteria from "Desi" cow dung. Based on physio-morphological and biochemical analysis, 32 Gram negative cocci, 18 Gram negative rods, 11 Gram positive rods, and 09 Gram positive cocci were identified.

Cow dung also contains beneficial microflora, most notably bacilli, lactobacilli, cocci, and a variety of known and unknown fungi and yeast (Kalpana Bhatt and Dinesh Kumar Maheshwari, 2019). This review will emphasise the importance of indigenous cow dung and its microbes in agriculture, industry, pharmaceuticals, and the environment.

Cow dung microbial diversity

Biologists have been interested in the microbial diversity of cow dung for over a century. *Bacillus, Bifidobacterium*, and *Lactobacillus* are some of the bacteria found in livestock guts.

In 2004, a researcher identified a novel species of xylanolytic, facultatively anaerobic, motile, gram-variable, sporulated rod bacterium *Paenibacillus flaviporus* from fresh and aged cow dung using 16S rRNA gene sequence analysis (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Cow dung contained *Lysinibacillus xylanilyticus, Micrococcus varians, Proteus mirabilis, Enterobacter aerogenes,* and *Bacillus species including Bacillus safensis, Bacillus cereus, Bacillus subtilis, Bacillus pumilus, Bacillus sphearicus, Bacillus macereans, Bacillus lateosporus,* and *Bacillus licheniformis*. In a later study from India, *Acinetobacter spp., Serratia sp., Alcaligenes sp.,* and *Pseudomonas sp.* were among the aerobic heterotrophic bacteria isolated and identified from cow dung (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Cow dung is also thought to be an ideal place for actinomycetes to reside. These actinomycetes are necessary components of cow dung and have been linked to the production of unfavourable flavours, odours, and colours. *Nocardia spp.* dominate the cow dung microflora. In addition, a large number of *Nocardioforms, Rhadococcus coprophillus,* have been isolated from the dung of domesticated herbivores. *Micromonospora chalcae and Pseudonocardia thermophila* were cellulose decomposers. According to the study, 30 actinomycetes species were isolated from fresh cow dung, and morphological and chemotaxonomic analysis revealed that they all belong to *Streptomyces spp* (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

In addition to bacteria and actinomycetes, many researchers have discovered fungi in cow dung. Some fungal species isolated from cow dung include *Alternaria sp., Cephalosporium sp., Cladosporium sp., Geotrichum sp., Monilia sp., Mucor sp., Penicillium sp., Rhizopus sp., Vericosporium spp., Sporotrichum sp., Thamnidum sp. Aspergillus sp*. species have been reported, including *Aspergillus niger, Aspergillus flavus, Aspergillus rapens, and Aspergillus fumigatus*, as well as *Rhizopus stolonifer, Mucor mucedo, Fusarium spp., and theobromae., Penicillum chrysogenum, Penicillum glabrum Pleurofragmium sp.,* and *Trichoderma harzianum* (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Historical Significance of cow and its products

The cow is the ideal animal in Brahma's creation, according to the Vedas. It is thought to be a symbol of motherhood. In Santana Vedic culture, the cow is the most revered animal. It gives us milk and byproducts, and its waste is worth as much as gold. All four Vedas mention the glory and benefits of the cow and her heavenly milk. In the Rig Veda, the cow is said to represent light and rays, whereas the Atharva Veda contains 33 crore deities. Cows, according to the holy text, bring happiness and purity into the home, as well as wealth and prosperity (Anonymous, 2022).

The various properties and therapeutic potentials of cow products were described in Ayurvedic originals such as Charak Samhita, Sushruta Samhita, Bhaisajya Ratnavali, and Arya-Bhishak. The Charak Samhita mentions cow milk for its ability to strengthen the seven Dhatus (tissues) Rasa (plasma), Rakta (blood), Mamsa (muscle), Meda (adipose tissue), Asthi (bone), Majja (bone marrow), and Shukra (reproductive tissue). It's also used to boost memory and immunity (Arti Prasad and Naresh Kothar, 2022). Cow ghee has traditionally been used to heal wounds, treat chronic fevers, and nourish the body's tissues and vital fluids. Fresh butter is thought to be beneficial in the treatment of skin diseases and other problems caused by blood impurity. Cow urine is widely used in Ayurvedic therapeutics in India due to its year-round availability, low cost, and special sanctity (Arti Prasad and Naresh Kothar, 2022).

The Charak Samhita mentions it as a regulator that governs several abdominal and dermatological disorders such as itching (Kandu), eczema (Vicharchika), and acne vulgaris (Yauvanpidika). Sushruta Samhita, on the other hand, described them as a cognition enhancer (Medhya) and reversal of certain cardiac (Hrid Roga), gastrointestinal (Udar Roga), and kidney-related issues (Arti Prasad and Naresh Kothar, 2022). Cowpathy, also known as Panchagavya Chikitsa in Ayurvedic literature, is an ancient medical system (Rajeswari *et al.,* 2016).

Panchagavya shown in Fig 2, which is made up of cow derivatives with various properties such as gomay (absorb heat), gomutra (heal), milk (easy to digest and does not flatten), yoghurt (destroy vaat & increase strength), and ghee (beneficial for eye and wound), was mentioned in the old Vedic script (Anonymous, 2022).

Cow dung analysis in lactating and heifer indigenous cows

According to one study, the pH of lactating cow dung is slightly alkaline in nature when compared to heifer cow dung. The pH values of heifer and lactating cow dung were 7.24±0.17 and 8.19±0.18, respectively (Nawal S. Rawat *et al.,* 2019). Manure's total solids or dry matter% content is a key determinant of its handling characteristics and relative nutrient content. The total dry matter percentages of lactating and heifer cow dung were found to be 18.49±0.58 and 19.51±0.57, respectively. In terms of dry matter percentage, there was no statistically significant difference (Nawal S. Rawat *et al.,* 2019).

Lactating cow dung contained significantly more moisture (81.51±0.27) than heifer dung (80.49±0.20). Moisture is a major factor in determining the quality of any manure or substrate (Nawal S. Rawat *et al.,* 2019). It was also discovered that the population of microorganisms in lactating cow dung is significantly higher than in heifer cow dung (Nawal S. Rawat *et al.,* 2019).

Importance of Indigenous cow dung

In agricultural uses

Cow dung, as previously stated, has also been used as an important source of organic fertiliser and in the production of biogas (Mishra *et al.,* 2022). It improves soil mineral status, increases plant resistance to pests and diseases, strengthens plant growth, and promotes other beneficial activities such as sulphur oxidation and phosphorous solubilization (Saurab Kishore Munshi, 2018). Ayurvet Research Foundation (ARF) based at village Chidana, district Sonipat, Haryana has been working since 2005 for the sustainable integration of agriculture and livestock for the benefit od farmers and society at large. Under NABARD sponsored organic farming project, it has been observed that vermicompost made out of cowdung improves the texture, water holding capacity, organic carbon content and microbiota of soil for enhanced productivity per acre of land.

Some of the bacteria isolated from cow dung have been shown to have antifungal properties (Sudhanshu S. Behera and Ramesh C. Ray, 2021). Among the cow dung isolates*, B. subtilis* strains are the most common isolates from culturable cow dung microflora in agriculture. Several findings have shown that these *B. subtilis* strains have antagonistic properties against phytopathogenic fungi such as *Fusarium soalni, Fusarium oxysporum,* and *Sclerotiorum, Botryodiplodia theobromae* (Radha and Rao, 2014; Sudhanshu S. Behera and Ramesh C. Ray, 2021; Kartikey Kumar Gupta *et al.,* 2016). It is not only had antifungal activity but also act against postharvest rot pathogens of yam tubers, and the strain also promoted root elongation in *Cicer arietinum* seedlings by up to 70-74% when compared to untreated seeds (Radha and Rao, 2014; Sudhanshu S. Behera and Ramesh C. Ray, 2021).

A researcher reported that seeds treated with cow dung inhibit the growth of pathogenic fungi. *Fusarium wilt* has been identified as a serious problem that causes 30-100% crop loss. The application of aqueous extract of cow dung inhibited the growth of fungal species such as *Alternaria alternata, F. oxyporium, Colletotrichum capsici, and Curvularia lunata*. It also inhibited the mycelial growth of plant pathogens such as *F. solani, F. oxyporium,* and *Sclerotinia sclerotiorum.* Two important strains isolated from cow dung, *Streptomyces cochorusii strain NF0919 and Bacillus amyloliquefaciens strain SB177*, were found to be very effective in controlling the rice sheath blight pathogen, *R. solani*, and red rot diseases caused by *Colletrotrichum falcatum* (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

An interesting observation that has been noticed that chickpea seeds coated with cow dung reduce the activities of cell wall-degrading enzymes (hydrolases) in a transcriptionally regulated manner, which in turn functions as a biocontrol measured for fungal growth in *C. arietinum* roots (Sudhanshu S. Behera and Ramesh C. Ray, 2021). Cow dung-based bacteria commonly use cell wall degrading enzymes such as (cellulase, chitinolytic, and polygalacturonase) and antifungal secondary metabolites (siderophore) to inhibit the growth of fungal pathogens (Sudhanshu S. Behera and Ramesh C. Ray, 2021). Chitinase, a lytic enzyme with antimicrobial metabolites, was found to be involved in the inhibition of these fungi's growth. Cow dung was also discovered to inhibit the conidial germination of *Bipolaris sorokinjan*a, which causes common root rot of small cereal grains (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Phytopathogenic nematodes are one of the significant agricultural pathogens. It was found that 219 bacterial strains from cow dung for nematicidal activity against the model nematode Caenorhabditis elegans, and 17 of these strains killed more than 90% of the tested nematode within 1 hour. *Alcaligenes faecalis, Bacillus cereus, Proteus penneri, Providencia rettgeri, Pseudomonas aeruginosa, Pseudomonas otitidis, Staphylococcus sciuri, Staphylococcus xylosus, Microbacterium aerolatum,* and *Pseudomonas beteli* were among the strains identified. 14 of these strains also inhibited *Meloidogyne incognita*, another nematode. For the first time, strains of the genera Proteus, Providencia, and Staphylococcus isolated from cow dung demonstrated nematicidal activity (Kartikey Kumar Gupta *et al.,* 2016).

Apart from the antifungal activities, plant growth promotion is another important feature of cow manure fertilization. Two important plant hormones that regulate plant growth and development are IAA and gibberellic acid. Some of the Gram-positive bacteria *B. amyloliquefaciens FZB42, Bacillus safensis, B. cereus, and B. subtilis, Lysinibacillus xylanilyticus* and *B. licheniformis* produced indole acetic acid (IAAs) (13). We also observed an increase in shoot number, roots and shoot length when the *Bacillus subtilis* culture suspension isolated from cow dung was applied to yam minisets. Another important property of cow dung is nutrient mobilization. There are few micro- and macro-nutrients that are not readily available to plants. Some of the microorganisms found in cow dung, such as thermostable *B. subtilis* strains, possess acidic and alkaline phosphatase activities that convert insoluble forms of P into soluble forms (Sudhanshu S. Behera and Ramesh C. Ray, 2021; Kartikey Kumar Gupta *et al.*, 2016). These P-solubilizing microorganisms include a wide range of bacteria, fungi, and actinomycetes, many of which are distributed in the rhizosphere (Sudhanshu S. Behera and Ramesh C. Ray, 2021). Study conducted at ARF also exhibits that some bacterial colonies had clear zones in the Pikovskaya medium, Figure 3.

Bacillus cereus, Bacillus subtilis, Lysinibacillus xylanilyticus were observed in solubilize P from insoluble tricalcium phosphate, Bacillus cereus strains have the potential to significantly increase maize shoot length and *Bacillus safensis, Bacillus cereus, Lysinibacillus xylanilyticus*, and *Bacillus licheniformis* improved root length significantly. All of the isolates significantly increased the total dry weight of the plants. Shoot and root length, as well as shoot and root dry weight, increased consistently.

Zinc deficiency is a major issue that causes poor plant growth and soil degradation. Cow dung bacteria mobilise insoluble forms of Zn in soil, making them easily accessible to plants (Sudhanshu S. Behera and Ramesh C. Ray, 2021). *Bacillus megaterium* was discovered to have the quality of Zn nutrient management, growth promotion, and Zn augmentation in soil by a researcher. An even more important feature of cow dung microflora is S oxidation. Thiobacillus bacteria are the most important and widespread S-oxidizing agents. Other microorganisms reported include *Bacillus sp., Klebsiella sp., and Pseudomonas sp.*, which aid in S oxidation (Sudhanshu S. Behera and Ramesh C. Ray, 2021). During study at ARF, zinc sobubilizing bacteria has been isolated from indegenous cow dung, Fig 4.

In industrial and commercial uses

Many microbial enzymes have been isolated and studied for industrial and commercial use. Cow dung isolates that produce enzymes such as protease, lipase, carboxymethylcellulase, xylanase, cellulase, amylase, gelatinase, urease, β-galactosidase, esterase lipase (Kartikey Kumnar Gupta *et al.*, 2016). Bacillus spp. isolated from cow dung can produce cellulose, carboxymethyl cellulose, and cellulase (Kartikey Kumnar Gupta *et al.*, 2016; Sudhanshu S. Behera and Ramesh C. Ray, 2021). CMCase is commonly found in the bioenergy, detergent, textile, food, and paper industries (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Xylanolytic bacteria are gaining commercial interest in a variety of industries, including enzyme-aided paper bleaching, ethanol production from plant biomass, animal feed additives, and bread production (Kartikey Kumnar Gupta *et al.*, 2016). *Paenibacillus favisporus sp.*, a xylanolytic bacteria found in cow dung, was discovered to produce a diverse array of hydrolytic enzymes such as xylanases, cellulases, amylases, gelatinase, urease, and -galactosidase (Kartikey Kumnar Gupta *et al.*, 2016). *Streptomyces spp.* isolated from cow faces produce a variety of industrially important enzymes such as amylase, caseinase, gelatinase, lipase, chitinase, and cellulase, according to a study (Sudhanshu S. Behera and Ramesh C. Ray, 2021). It was reported that a neutral and thermostable -amylase isolated from cow dung was incorporated into cattle feed for compatibility with the gut environment and easy digestibility (Sudhanshu S. Behera and Ramesh C. Ray, 2021). Exo-polygalacturonase, another enzyme produced by B. subtilis isolated from cow dung, was comparable to commercially available pectinase. It increases carrot juice yield when compared to juice extracted with commercial Pectinase (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

The production of bio-hydrogen and bio-pigments was another important industrial use of cow dung. Biohydrogen production is a cutting-edge biofuel technology that uses cow dung-based microorganisms to produce biohydrogen. Cultures enriched with cow dung compost have been reported to be ideal for hydrogen production from cellulose (Nan-Qi Ren *et al.*, 2010). Rumen fluid is capable of accumulating thermophilic, cellulolytic, and hydrogenogenic nutrients, and aids in the production of biohydrogen (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Colourant production from biological agents for food and textile has gained popularity in recent years. Bio pigments produced by microorganisms are preferred over those produced by plants.

Bacillus and Pseudomonas isolates from cow dung exhibited deep red pigmentation in a nutrient broth culture medium (Sudhanshu S. Behera and Ramesh C. Ray, 2021; Hizbullahi M Usman *et al.*, 2017). Many businesses are concerned about fruit spoilage microorganisms such as *E. coli, S. aureus, Proteus vulgaris and Salmonella Typhi*.

Fig.1 Gujrat native breed (Gir) (Kim Irvine, 2019)

Fig.2 Ingredients of Panchagavya

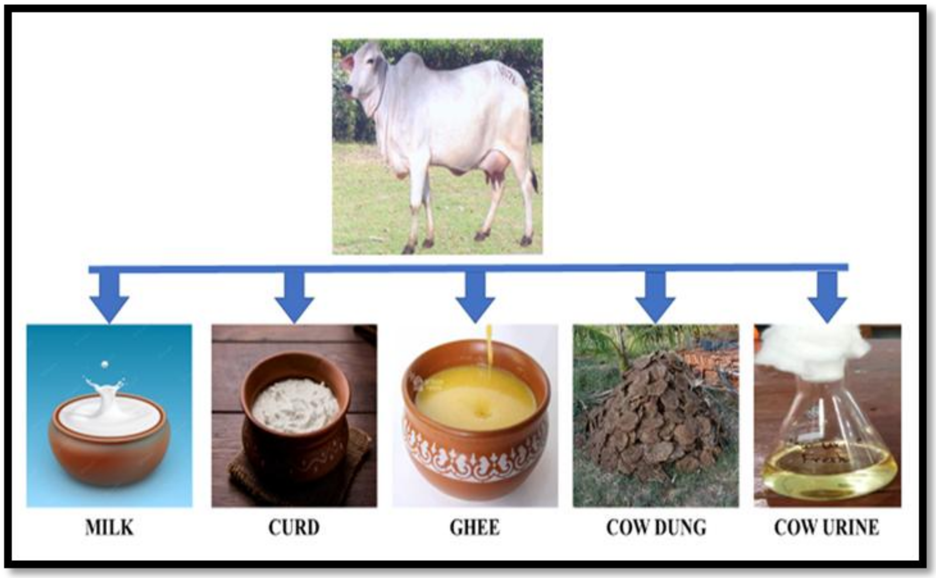
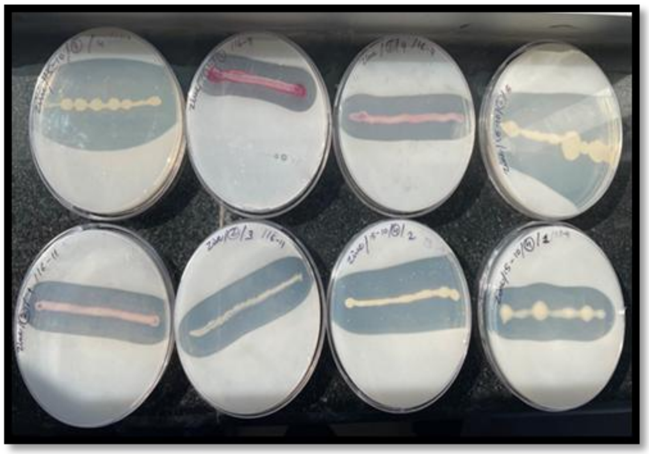


Fig.3 Colonies on Pikovskaya medium

Fig.4 Colonies on zinc solubilizing agar



Bacteriocin-producing cow dung-based lactic acid bacteria were found to be effective against the aforementioned pathogens. These are some of the important uses of the cow and its associated microbiota for industrial applications.

In Therapeutic uses

Cow dung has antiseptic and prophylactic (disease-prevention) properties. It kills the microorganism responsible for disease and putrefaction (Kartikey Kumnar Gupta *et al.,* 2016). Cow dung acts as an antibacterial agent against several Gram-positive bacteria, including *Bacillus subtilis, Bacillus cereus, Bacillus sphaericus, Enterococcus faecalis, Staphylococcus epidermidis, Staphylococcus aureus, Micrococcus luteus, and E. coli, Pseudomonas aeruginosa, Proteus vulgaris, and Salmonella* bacteria (Sudhanshu S. Behera and Ramesh C. Ray, 2021). The mechanism of antimicrobial activity involves disrupting the integrity of the cell membrane and surface permeability, preventing nutrient uptake, and inducing pore formation, which kills the bacterial cells (Sudhanshu S. Behera and Ramesh C. Ray, 2021). Cow dung contains antifungal compounds that prevent the growth of coprophilous fungi. Patulodine-like compounds, CK2108A and CK2801B, are produced by *Eupenicillium bovifimosum* in cow dung and have significant antifungal activity (Kartikey Kumnar Gupta *et al.,* 2016). The medicinal properties of five cow-derived products known as panchgavya, namely milk, ghee, curd, dung, and urine, are supported by their use in the preparation of various herbal medicines (Kartikey Kumnar Gupta *et al.,* 2016; Edwin Jarald, 2008). Panchgavya therapy employs these five products alone or in combination with herbal or mineral drugs to treat a variety of diseases such as flu, allergies, colds, cough, asthma, renal disorders, gastrointestinal tract disorders, acidity, ulcer, wound healing, heart diseases, skin infections, tuberculosis, chickenpox, hepatitis, leprosy, and a variety of other bacterial and viral infections.

A researcher discovered a large number of *Enterococci* with antilisterial activity in cow dung water. One isolated strain of *Enterococcus faecalis V24* was discovered to produce a heat stable, largely hydrophobic antimicrobial substance with significant antimicrobial activity against pathogenic Gram-negative bacteria (Kartikey Kumnar Gupta *et al.,* 2016, Laukova *et al.,* 1998). *Mycobacterium vaccae*, a nonpathogenic bacterium recovered in cow dung, has antidepressant properties. When inhaled, it stimulated neuron growth, which stimulated the production of serotonin and norepinephrine in the brain. Its effects on anxiety and learning ability were also tested on mice, and it produced positive results when the mice were fed live *M. vaccae* (Kartikey Kumnar Gupta *et al.,* 2016).

In environmental uses

Cow dung and its microorganisms are used in a variety of environmental issues, including biodegradation, bioremediation, bioadsorption, and biosorption. Cow dung contains a diverse group of microorganisms, including *Acinetobacter, Bacillus, Pseudomonas, Serratia, and Alcaligenes spp*., providing a mechanism for microbial pollution degradation (Kartikey Kumnar Gupta *et al.*, 2016). Cow dung isolates from the genera *Pseudomonas, Bacillus, Citrobacter, Micrococcus, Vibrio, Flavobacterium, Corynebacterium Rhizopus, Aspergillus*, *Penicillium, Fusarium, Saccharomyces, and Mucor sp*. decrease petroleum hydrocarbons in polluted mangrove soil, according to a researcher (Frank Anayo Orji, 2012; Kartikey Kumnar Gupta *et al.,* 2016).

The natural ability of cow dung microflora to degrade hydrocarbons in soil contaminated with engine oil, where total petroleum hydrocarbon reduced up to 81 % by the metabolic activities of cow dung microorganisms such as *Bacillus, Staphylococcus, Pseudomonas, Flaviobacterium, Arthobacter, Enterobacter, Trichoderma, Mucor, and Aspergillus spp.* Studies suggested that using cow dung in an appropriate concentration could be very effective in biodegrading motor oil-contaminated water. *Cyathus stercoreus,* isolated from aged cow dung, is capable of degrading lignocelluloses in vitro as well as the antibiotic enrofloxacin, which is found in biomedical waste. In 2008, researchers demonstrated complete biodegradation of biomedical waste in the culture medium of a cow dung fungus, *Periconiella* (Kartikey Kumnar Gupta *et al.,* 2016). A study published in 2009 reported that cow dung microflora aid in the bioremediation of hazardous compounds such as benzene, toluene, xylene, phenol, and halogenated compounds. *Pseudomonas putida MHF 7109 and Bacillus sp.* isolated from cow dung were found to be effective for benzene biodegradation and halogenated compound (2, 2-dichloropropionic acid) degradation, respectively

Few studies have been published describing the importance of cow dung microbiota in pesticide disposal. Cow dung microbial consortium containing bacteria, fungi, and actinomycetes was found to be effective in degrading phenol at concentrations ranging from 100 to 1000ppm. Two bacteria found in the microbial consortium, *Pseudomonas plecoglossicida and Pseudomonas aeruginosa*, have been found to completely degrade hazardous chemicals such as cypermethrin and chlorpyrifos. In a study, cow dung slurry has been used in a 1:10 ratio for bioremediation of pesticides such as chlorpyrifos, cypermethrin, fenvalerate, and trichlopyr butoxyethyl ester, and discovered that all of these pesticides are degraded into intermediate or less harmful compounds (Kartikey Kumnar Gupta *et al.,* 2016; Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Cow dung and its microorganisms have recently been used for heavy metal remediation, including chromium, strontium, and arsenic. The methylation process can be used to detoxify arsenic. Bacteria's ability to methylate arsenic into volatile products, primarily arsine in the form of dimethylarsine, was discovered in 1995. Mohapatra *et al.,* (2008) demonstrated that cow dung can serve as a major substrate for bacterial growth during the volatilization removal of arsenic from arsenic-rich sludge (Kartikey Kumnar Gupta *et al.,* 2016; Sudhanshu S. Behera and Ramesh C. Ray, 2021).

Dry cow dung powder was recently used as an adsorption source for the removal of chromium from aqueous solution and achieved 73.8% chromium removal (Kartikey Kumnar Gupta *et al.*, 2016). Heavy metals (e.g., Zn, Cu, Pb, Ni, Cd, etc.) in wastewater and industrial effluents are a major environmental concern. Cow dung ash is a low-cost and environmentally friendly absorbent. As a result, the cow dung could be used as an effective adsorbent in the removal of heavy metals from wastewater and the environment (Sudhanshu S. Behera and Ramesh C. Ray, 2021).

For over a century, biologists have been influenced by the microbial diversity of cow dung. It has also been used extensively as an organic fertilizer and in the production of biogas. It improves soil mineral status, strengthens plant growth, and promotes other beneficial activities such as sulphur oxidation and phosphorous solubilization. Cows have a high potential for organic manure, which is required for organic farming, and in the near future, these indigenous cows will be the backbone of organic farming and the agricultural economy in India Cow dung and its microorganisms have recently been used to remediate heavy metals such as chromium, strontium, and arsenic. A large number of microbial enzymes have been isolated and studied for therapeutic, industrial and commercial applications.

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