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Green Synthesis, Characterization and Applications of Nanoparticles Using Cow Urine, Cow Dung and Vermiwash: Review of Article

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ABSTRACT: Green synthesis has recently drawn significant interest as a viable, evolving, and environmentally friendly method for synthesis of variety of nanomaterials, including metal/metal oxide nanoparticles. In this review, we summed up the general protocols and mechanism of green synthesis and mechanism of green synthesis routes, especially for Silver(Ag), Silver oxide(Ag_2O), Cadmium(Cd), Copper(Cu), Copper ferrite($CuFe_2O_4$), Palladium(Pd), and Graphene nanomaterials/nanoparticles using cow urine[1] and Zinc oxide(ZnO), C dots and Amorphous Nano-silica and other nanoparticles using cow dung extract and Copper oxide, silver, gold, molybdenum doped TiO_2 nanoparticles from vermiwash. We carefully examined the primary function of biological elements found in cow dung, cow urine and vermiwash. Vermiwash is the leachate that comes from vermicomposting units. Because it is a natural substance with brown colour and contains a lot of nutrients for plants, it can be used as liquid fertilizer. Additionally, the humic acid it contains aids in the growth of plants. In the solvent system, these basic biomolecules serve as stabilizing and reducing agents[2]. Characterization techniques are also used to discuss surface shape, phase development, and nanoparticle stability. Lastly, we talked about the potential applications of these synthesized nanoparticles as an anticancer agent, antimicrobial activity, photocatalyst and a drug delivery system.

KEYWORDS: Applications**,** Characterization, Green synthesis, Nanoparticles.

INTRODUCTION

Since ancient times, cows have been revered in Indian culture as sacred and venerable beings known as "KAMADHENU," which means the mother of all spiritual creatures. Due to its significance in mythical, spiritual, and medicinal aspects, Hindus employ panchagavya (urine, ghee, milk, curd, and dung), which is obtained from cows and is beneficial in several ways as a food supplement, spiritual applications, and medications[3]. Modern studies on cow urine have shown that it can treat a wide range of illnesses, including joint pain, high blood pressure, diabetes, heart disease, cancer, thyroid, asthma, psoriasis, skin inflammation, headache, ulcer, and gynecological issues[3]. Additionally, cow urine has promising medical applications as cancer biosensors, anticancer, antibacterial, antioxidant, and anti-anthelmintic agents. Consequently, it has been demonstrated that cow pee is a powerful and effective medicinal alternative for treating a number of illnesses. Due to its intriguing and diverse uses in the fields of biomedicine, bio-imaging, biosensor, optics, semiconductors, solar cells, catalysis, electrochemistry, ceramics, fuels, biotechnology, agribusiness, pharmaceuticals, textile industry, and water treatment, nanotechnology has recently been growing quickly[3]. This viewpoint uses cow pee-mediated nanoparticles in restorative recordings to give an idea of the environmentally friendly synthesis of nanoparticles using cow urine to advance nanoparticles biological qualities. Here, we talked about the latest findings in nanoparticle green synthesis research and its advantages over chemical synthesis techniques. Presenting thorough methods for creating green synthesis nanoparticles from cow pee and outlining their numerous applications is the main objective of this review.

Furthermore, the term "cow dung" describes the undigested food scraps that herbivorous bovine animals expel. It is a 3:1 mixture of pee and feces and is mostly composed of lignin, cellulose, and hemicelluloses. It also contains trace levels of 24 various minerals, such as manganese, copper, cobalt, magnesium, iron, sulfur, potassium, nitrogen, and magnesium. The native Indian cow also has higher levels of calcium, phosphorus, zinc, and copper than crossbred cows. Numerous bacteria can be found in cow manure, including (Lactobacillus spp., Corynebacterium spp., and Bacillus spp.), protozoa, and yeast (Saccharomyces and Candida). Citrobacter koseri, Enterobacter aerogenes, Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoni, Kluyvera spp., Morgarella morganii, Pasteurella spp., Providencia alcaligenes, Providencia stuartii, and Pseudomonas spp. were among the many bacterial genera.

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Cow dung is used in Indian agriculture as manure, biofertilizer, biopesticides, pest repellents, and a source of energy. Ayurveda suggests it may cleanse all of nature's wastes. In India, the cow (B. indicus), which yields milk, is therefore not only regarded as a milk-producing animal but also as Kamdhenu, the mother of all. The thorough investigation of cow dung is gaining popularity worldwide, and attempts have been made to harness its potential for the production of energy and medications. The purpose of the review is to draw attention to the possible applications of cow dung for human welfare, specifically in the areas of energy, agriculture, the environment, and medicine[4].

A rich population of earthworms vermicompost organic materials to create vermiwash, a natural product. The raw organic matter used for vermicomposting affects the vermicompost/vermiwash's composition and quality. Vermiwash and vermicompost made from the same organic matter have nearly identical compositions. The two products are distinguished by a multitude of substances, including hormones, mucus, enzymes, vitamins, proteins, various macro and micronutrients, and a multitude of bacteria. Because it contains vital antimicrobial and anti-pest compounds, it can be used not only as a fertilizer to increase crop yields but also for disease prevention and pest control. Numerous minerals, vitamins, and growth hormones found in vermiwash and vermicompost have anti-insect and anti-disease properties (MacHfudz et al., 2020). Vermiwash, the liquid form of vermicompost, is more appropriate than applying it solidly because of its bioavailability, which allows it to swiftly reach the desired area surrounding plant roots[5].

SCOPE OF THE REVIEW

This review's objective is to provide a current report on nanoparticles mediated by cow dung, cow urine, and vermiwash, as well as their potentially wide range of uses in agriculture, including co-energy products like manure, biofertilizer, biopesticides, and pest repellents, as well as antimicrobial, antioxidant, anticancer, and photocatalytic activities. The structural features of the nanoparticles, such as their stability, shape, size, chemical makeup, and physical attributes, were also discussed. However, a quick study of typical protocols was carried out, which included basic generic approaches for nanoparticles mediated by vermiwash, urine, and cow dung.

BIOLOGYCAL SYNTHESIS OF NANOPARTICLES

Numerous synthetic methods have so far been investigated for the production of nanoparticles. Therein, top-down and bottom-up are the two primary methods by which scientists create nanoparticles with fascinating and diverse applications. While nanoparticles are produced from molecules or atoms in bottom-up procedures, metal reduces up to the nano level in topdown approaches. The use of well-known chemical and physical techniques, such as coprecipitation, sol-gel, sonochemical, laser ablation, hydration techniques, solution combustion, reflux method, polyol, solvothermal, chemical lessening, ion-exchange, chemical vapour decomposition, colloidal method, spray pyrolysis, mechanical processing, physical vapour deposition, sputtering, laser pyrolysis, microemulsion, photochemical, and electrochemical. However, biogenic strategies lead to synthesized nanoparticles over known chemical and physical strategies due to their immense benefits. Most of the chemical and physical strategies include the utilization of costly and toxic additives/solvents, highly toxic reducing and stabilizing agents, which can cause a noxious effect on both environment and human life. In contrast, biogenic synthesis of nanoparticles is a one-pot, swift, safer, and biocompatible or ecobenevolent bio-reduction technique that requires relatively minimum energy to start the reaction. In particular, cow urine is acknowledged around the world as a pharmaceutical over close around all kinds of disease, the hormones, vitamins, and acids found in cow urine bio-reduce the metal salt into nanoparticle. An original strategy and environmentally benign method for creating nanoparticles is biological synthesis. Additionally, it has been widely documented that cow dung may include a variety of microbial enzymes and antibacterial compounds. Nanoparticle production from cow dung extract(biogenic extracts) is a straight forward and inexpensive procedure. Cow dung extract is found to include a variety of bioactive chemicals, as mentioned in the previous section. Some of these compounds have been reported as potential stabilizers and reducers for the creation of different metallic nanoparticles. Despite the fact that the precise mechanisms of biosynthesis are not well understood. However, it has been noted that a number of compounds in the biological extract, including amines, phenol, enzymes, and other proteins, have a lowering impact on metal salts, which may be the cause. An original strategy and environmentally benign method for creating nanoparticles is biological synthesis.

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PROTOCOL FOR BIOGENIC SYNTHESIS OF NANOPARTICLES FROM COW URINE AND COW DUNG AND VERMIWASH

The size and morphology of synthetic nanoparticles determine the qualities that are required. As a result, nanoparticles are created by changing a few variables, including pH, temperature, response time, concentrations of the metal salt, cow urine, cow dung and vermiwash. There is no need to add externally toxic stabilizing/capping additives because the cow urine contains a large number of constituents that act as bio-reducing and/or stabilising agents, including copper, iron, nitrogen, manganese, sulphur, carbolic acid, chlorine, silicon, magnesium, calcium salts, citric acid, creatinine, enzymes, mineral salts, hormones, vitamins like A, B, C, D, and E, gold acids, and uric acid, among others. Cow pee or cow dung is easily combined with various concentrations of chosen metal salt solutions at room temperature, and their conversion to the appropriate nanoparticles occurs in a matter of minutes using an ineffective, one-pot, sustainable, and environmentally friendly method.

Vermiwash, a cheap liquid extract made from vermicomposting beds, is applied to crop plants as an organic fertilizer. It is often the washing of earthworms found in the medium that is collected after water has passed through the various worm culture unit layers. The raw organic matter used for vermicomposting affects the vermiwash's composition and quality. Vermiwash and vermicompost made from the same organic matter have nearly identical compositions. The two products are distinguished by a variety of substances, including hormones, mucus, enzymes, vitamins, proteins, various macro and micronutrients, and microorganisms. Rich in vitamins, growth hormones, and other nutrients, it suppresses pests and diseases. It was discovered that earthworm vermiwash exhibited strong antibacterial properties. Enzymes like phosphatase, amylase, protease, and urease are found in vermiwash, a byproduct of vermicompost, which is one of the most straight forward and inexpensive biological sources.

MECHANISM FOR BIOLOGICAL SYNTHESIS OF NANOPARTICLES FROM COW URINE, COW DUNG AND VERMIWASH

The bio-reduction of metal to the nanoscale is the basis for biological production of nanoparticles, and cow urine, cow dung and vermiwash(biological extracts) can produce these nanoparticles. In the biological synthesis of nanoparticles, commonly metal particle comes in contact with biomolecules which are existed in these biological extracts and the negative side of biomolecule gets pulled in the positive charge metal and this complex form stabilized through interaction. A few components of these were described, including biomolecules that function as stabilizing, capping, and/or bio-reducing agents. The role of these biomolecules varies depending on their structure and reactive sides. The interaction results in the precipitation to form stable complexes and after calcination yields the desired nanoparticles.

CHARACTERIZATION TECHNIQUES FOR NANOPARTICLES SYNTHESIZED FROM COW DUNG, COW URINE AND VERMIWASH EXTRACT

The biologically synthesized nanoparticles are commonly explored based on their stability, size, morphology, dispersity, and surface area using diverse characterization techniques. UV-visible spectroscopic data, Fourier transform infrared spectroscopy (FT-IR), Xray powder diffraction (XRD), X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM), energy-dispersive X-ray spectroscopy (EDS), scanning electron microscopy (SEM) and transmission electron microscopy (TEM) images, dynamic light scattering (DLS), atomic absorption spectroscopy (AAS), vibrating sample magnetometer (VSM), BrunauerEmmett-Teller (BET), thermogravimetric analysis (TGA), zeta potential and other characterization tools reveal the formation of green synthesized nanoparticles and their growth, surface area, size, shape and magnetic properties.

APPLICATIONS

Recently, cow urine, cow dung and vermiwash mediated nanoparticles may have versatile applications depending on the diverse features they manifest; therefore, we have portrayed their effective applications in anti-asthma, antimicrobial, antioxidant, anticancer, and photocatalytic activity to emphasize their momentous outcomes as guidance to upcoming researchers for future standpoints.

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1. APPLICATIONS OF COW URINE MEDIATED NANOPARTICLE

Recently, cow urine mediated nanoparticles may have versatile applications depending on the diverse features they manifest; therefore, Harshal Dabhane et al.[3] have portrayed their effective applications in anti-asthma, antimicrobial, antioxidant, anticancer, and photocatalytic activity to emphasize their momentous outcomes as guidance to upcoming researchers for future standpoints.

A.S. Santosh et al.[6] described the synthesis of silver(CoUSiN particles) using cow urine. The antimicrobial properties of CoUSiN particles using Gram-positive and Gram-negative bacteria such as E.coil and ERSA were evaluated. The study also establisted blood compatibility of CoUSiN particles.

Sambada. B. Wakare et al.[7] have broadly discussed about nanomaterials which is synthesized by using cow urine such as Silver, Copper, Copper Oxide, Palladium, Graphene etc. Along with synthesis, they studied different characterizations techniques which gives information of size, shape, morphology, stability of the synthesized nanoparticles. Biosynthesized nanomaterials have a potential to explore their uses in biomedical field as compared other area of concerns. Biosynthesized nanomaterials show antimicrobial activity, antibacterial, antineoplastic, Nano catalyst, dye degradation activities.

SP Vinay et al.[8] have successfully synthesized silver oxide nanoparticles using cow urine by a combustion method at 500^0c which is characterized by maens of XRD, FTIR, UV-vis, SEM, EDAX and TEM and have tested for photoluminescence and for photocatalytic and biological activities.

Harshal Dabhane et al.[9] described the novel biogenic approach for the synthesis of ZnO nanoparticles using cow urine as a reducing and stabilizing agent, the confirmation and characterization of the synthesized material were accomplished using spectroscopic and microscopic techniques.

Abdul Malek et al.[10] described the hydrogen production from both human and cow urine. The total volume of hydrogen production increases with amounts of Al salt and $NaBH_4$ used. Use of fresh urine (both human and cow) yields higher hydrogen production kinetics. Interestingly, cow urine is more resilient to ageing related reduction in hydrogen production.

Nandisha P S et al.[11] have synthesized CuO nano bundles- like structures from Gomutra(cow urine), acting as reducing and capping agents to control the structure and morphology. And which is characterized by XRD, SEM, EDAX, UV-vis, FT-IR, BET, and PL-Spectroscopy. CuO nano bundles also show good catalytic behavior for reducing 4-nitrophenol in the ultrasonication method.

Senthilkumar Palanisamy et al.[12] have described the pregnant cow urine is an active source of antimicrobial agents that is used for fabricating chitosan coated Ag/AgCl nanoparticles. These PCU@C-Ag/AgCl nanoaparticles were physicochemically characterized and evaluated for antimicrobial activity against selected respiratory tract infection.

Hiremath, N.G. et al.[13] have biologically synthesized zinc oxide nanoparticles, iron oxide nanoparticles, and the zinc-iron nanoparticle composite and displayed promising anticancer and anti-inflammatory effects without showing any indications of toxicity.

Ritesh Verma et al.[14] synthesized ZnO nanoparticles using cow urine as a reducing agent. Xray diffraction showed formational and structural superiority. The antimicrobial activity of ZnO NPs was observed to be effective against different pathogenic bacteria

SN Raghavendra et al.[15] have synthesized Silver nanoparticles of 22-40nm size using goat, cow and buffalo urine. These nanoparticles are conjugated with a fungicide (Mancozeb). The fungicide conjugated AgNPs drastically reduce the amount of fungicide to be applied against Colletotrichum gloeosporioides, which in turn reduce the hazardous effect caused by fungicides.

Pankaj Chamoli et al.[16] have reported synthesis of Graphene via wet chemical route needs chemical reduction of graphene oxide in the presence of reducing agents to grapheme sheet.

Vothani Sarath Babu et al.[17] have developed and evaluated nanoparticulate drug delivery system of highly cow urine soluble drug Isoniazed by using sodium alginate polymer were prepared by two techniques cross-linking method and solvent evaporation method.

CA Pawar et al.[18] have synthesized gold nanoparticles by reducing Au ions using the liquid metabolic waste of Indian Gir cow(A-2) urine. The synthesized bio-inspired AuNPs show potential antimicrobial and antioxidant activities.

Soumya Menon et al.[19] have reported the green combination of biosynthesized selenium nanoparticles utilizing aqueous extract of cow urine as a green technique with no external chemicals, reagents, or surfactants. which is further used for various pharmaceutical or industrial applications.

B Ranjitkumar et al.[20] described the green combustion pathway for Ag adopded ZnO nanoparticles preparation using honey and cow urine. Cow urine and honey played a crucial role in the process of combustion as chelating and gelling agents. The synthesized Ag doped ZnO nanoparticles characterized by XRD, FE-SEM, TEM, UV-vis, FTIR, and TGA .

Shareefraza J Ukkund et al.[21] have synthesized panchakavya using cow dung, cow urine, cow ghee, milk, curd and banana. Silver nitrate is treated with panchakavya to synthesize silver nanoparticles where in panchakavya act as reducing agent. The synthesized silver nanoparticles characterized by UV-vis, XRD, SEM and AFM. The silver nanoparticles are then used against napkins containing urine sample for antimicrobial activity.

Mukesh Nimba Padvi et al.[22] have synthesized CuO nanoparticles using cow urine. It is seen that the prepared nanoparticles exhibit excellent antimicrobial activity against test microorganisms such as Staphylococcus aureus, Klebsiella pneumonia, and Pseudomonas aeruginosa.also anti-cancer avtivity against MCF7 cell lines.

Prashant D. Sarvalkar et al.[23] have successfully synthesized Ag nanoparticles using Indian cow(A-2) urine. The biosynthesized Ag nanoparticles are potent catalyst for organic transformation reaction and which is used as a photocatalytic for degradation of harzardous organic dyes such as methylene blue and crystal violet.

Venkateshwaran Gopal et al.[24] have successfully accomplished green synthesis of $ZrO_2Bi_2O_3$ photocatalyst for the degradation of 2,4-D from aqueous solution.

H. J. Amith Yadav et al.[25] have prepared CeO2 nanoparticles were synthesized by combustion using fuel as cow urine and used for the advanced forensic and display applications.

2. APPLICATIONS OF COW DUNG MEDIATED NANOPARTICLES

Zoya Javed et al. [26] have studied, zinc oxide nanoparticles (ZnO) were synthesized using cow dung extract to apply sustainable agriculture from rural resources. Studies on their antibacterial potential against E. coli DH 5 alpha indicated lower antimicrobial activities than the bulk Zn and commercial Zn nanoparticles. Compared with control and commercial ZnO nanoparticles, the maximum seed germination, root length, and shoot length were observed after the priming of synthesized ZnO NPs.

Jayachamarajapura Pranesh Shubha et al. [27] have reported the efficacious synthesis of ZnO nanoparticles, using an ecofriendly, facile, and one-pot combustion of cow dung method. The synthesized material is characterized by using various techniques such as XRD, FTIR, UV, FESEM, and EDX. The as-prepared sample is examined as a photo-catalyst for the photodecomposition of MB and AZ dyes, deleterious industrial effluents. The green synthesized ZnO NPs could be employed as a promising candidate for remediation of wastewater and related photo-catalytic applications.

Luqmon Azeez et al.[28] have reported the implications of silver nanoparticles (AgNPs) and cow-dung contamination on water quality and oxidative perturbations in antioxidant biomarkers in the exposed Clarias gariepinus. They concluded that AgNPs posed a challenging environment for C. gariepinus to thrive.

Asfaw Firehiwot et al.[29] have successfully synthesized the zinc oxide nanoparticles using cow dung and which is characterized by XRD and FTIR. The presence of a different biological component in cows dung as a fuel for the synthesis of ZnO nanoparticles by a combustion method at 600^0c for 30 seconds. The synthesized ZnO nanoparticles exhibit a good antibacterial activity for gram-positive bacteria staphylococcus aureus by the disc diffusion method.

Mahmoud A Sliem et al.[30] have described the introducing a simple and rapid way with high profit not only to reduce expenses and efforts, but also to guarantee safety and eco-friendly biogas source. Thus, the effect of nanoferrites, as a source of metal ion, on biogas production rate was studied. Nanoferrites MFe_2O_4 (M = Fe, Ni, Co) were synthesized via a modified aqueous coprecipitation method under alkaline conditions using monoisopropanolamine (MIPA) as a base and capping agent. $CoFe_2O_4$ nanoparticles showed the greatest enhanced effect on the cumulative biogas production, followed by Fe_2O_4 nanoparticles.

Dhanesh Gandhi Arumugam et al.[31] have studied, biosynthesis of Copper nanoparticles using Indian traditional medicine, Panchagavya is used which is eco-friendly, simple, cost effective and non-toxic. Copper sulphate (25 mM) solution was mixed with Panchagavya filtrate for the synthesis of Copper nanoparticles. In addition, they studied the antioxidant and also cytotoxicity activity.

Cui Ms et al.[32] have described the micro-catalytic ozonation with nano-Fe3O4@CDA as a catalyst was demonstrated to be an effective advanced oxidation technology for the degradation of refractory pollutants in the biologically pre-treated leachate. Under the optimal conditions of nano-Fe3O4@CDA dosage of 0.8 g/L, input ozone of 3.0 g/L, and reaction time of 120 min, the COD and color number (CN) removal reached 53% and 89%, respectively, while the BOD5/COD increased from 0.05 to 0.32. The refractory compounds, e.g. humic-like

Zheng Zhang et al.[33] have reported the N-doped carbon materials are promising metal-free catalysts for the oxygen reduction reaction (ORR) in fuel cells. Here in, they reported a low-cost and scalable synthesis procedure to prepare a highly active N-doped carbon ORR catalyst using only cow dung as a source of carbon and nitrogen. The obtained catalyst produced high ORR activity comparable to commercial Pt/C in a 0.1 M KOH solution regarding both ORR onset potential and half-wave potential, and had excellent tolerance to methanol crossover as well as a stable ORR cycling performance. Furthermore, the use of cow dung puts a source of greenhouse gas pollution to good use as an ORR catalyst for clean energy production in fuel cells

Quanfu Yao et al.[34] have reported a polymer coating strategy for achieving cow dungderived N-halamine-modified biochars for use in bacterial decontamination. Using BET, FT-IR, XPS, SEM, and elemental analysis, the cow dung-derived biochars as well as the N-halaminecoating on them were fully characterized. The N-halamine coatings were regulated by tuning the reaction conditions. The final biochars were examined in terms of their antibacterial action against E. coli and S. aureus.

Raksha Choudhary et al.[35] have developed a nanodisc shaped nanocomposite based on WO3modified carbon nanosheets decorated with PdNPs by a simple and ecofriendly method. The synthesized Pd@WO3-NDs was utilized for the fabrication of rechargeable Zn–air batteries (in aqueous phase) and an all-solid-state battery to power up a 4.0 V LED. Moving toward different applications of the proposed catalyst, it was also employed for overall water splitting powered by the same all-solid-state Zn–air battery.

Puja Singh et al.[36] have described the Fe_2O_3 nanoparticles co-digested with cow dung, kitchen waste, and flower waste found to improve the quality of fertility of the soil. The effect was quite pronounced as the combination of flower waste, and Fe_2O_3 nanoparticles showed excellent results in the growth of tomato plant. According to our data, the flower waste + Fe_2O_3 nanoparticles combination and cow dung + Fe_2O_3 nanoparticles were effective for inducing plant growth. Improvised nano biofertilizers can be useful in future agricultural applications.

Quanfu Yao et al.[37] have reported the cow dung-based biochar serves as a green adsorbent to recover copper ions from wastewater, and in situ reduce Cu^{2+} ions to CuO and Cu+ Nanoparticles with narrow size distributions. The cow dung-based biochar and biochar/Cu nanoparticles were fully characterized by FTIR, XPS, SEM, TEM, STEM, mapping, and XRD analysis.

Prashant Dubey et al.[38] have reported that cow dung is employed as a biowaste resource to create extremely porous and conductive carbon with a 3D structure and linked pores. The CDPC is employed as a potential electrode for supercapacitors because of its remarkable porosity.

Kiran Kavalli et al.[39] have studied, green synthesis of zinc oxide nanoparticles using cow dung as fuel, through combustion. Synthesized material was characterized by FTIR, XRD, UV, and FESEM.

Samesh Samir Ali et al.[40] have investigated the effect of cobalt oxide nanoparticles (Co_3O_4NPs) supplementation on anaerobic microbial population changes and anaerobic digestion (AD) performance and production. Co_3O_4-NPs (3 mg/L) showed the maximum enhancement of biogas yield over the cow dung (CD) as control and the co-digestion process of CD with water hyacinth (WH) by 58.9 and 27.2 %, respectively. Furthermore, methane (CH4) yield was enhanced by 89.96 and 43.4 % over CD and co-digestion processes, respectively. Therefore, nanoparticle supplementation to the AD process can be considered a promising approach to enhance biogas and CH_4.

Choudhary Rakshaet et al.[41] have fabricated a highly efficient, economic, nano disc shaped trifunctional electrocatalyst using a tungsten trioxide modified carbon nanosheet decorated with palladium nanoparticles. The beauty of this work is that a special carbon precursor is used for the synthesis of the electrocatalyst, a waste material, i.e., cow dung. The performance of the cow dung derived nano disc electrocatalyst (Pd@WO_3-NDs) toward oxygen evolution reaction (OER), oxygen reduction reaction (ORR), and hydrogen evolution reaction (HER)

Jothi Ramalingam Rajabathar et al.[42] have produced hierarchical PAC at different activation temperatures in the range of 600 to 900 °C by using cow dung (CD) waste as a precursor, and H_3PO_4 is adopted as the nonconventional activating agent to obtain large surface area values. The as-prepared cow dung-based PAC (CDPAC) is graphitic in nature with mixed micro- and mesoporous textures.

K Manjula Rani et al.[43] have synthesized nano-sized silica from cow dung ash, which has good potential source of silica. The silica from the cow dung was converted into sodium silicate and then the SiO2 Precipitated in a controlled manner using surfactant. The nano sized amorphous silica was characterized using SEM, EDX and XRD data.

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Kingsley O. Iwuozor et al.[44] described, the application of cow dung-based adsorbent for the removal of pollutants from water was reviewed. The adsorbents were used in their unmodified state, biochars, or activated carbon. From this study, it can be deduced that cow dung-based adsorbents have exhibited good potential as an adsorbent for the mitigation of pollutants from water.

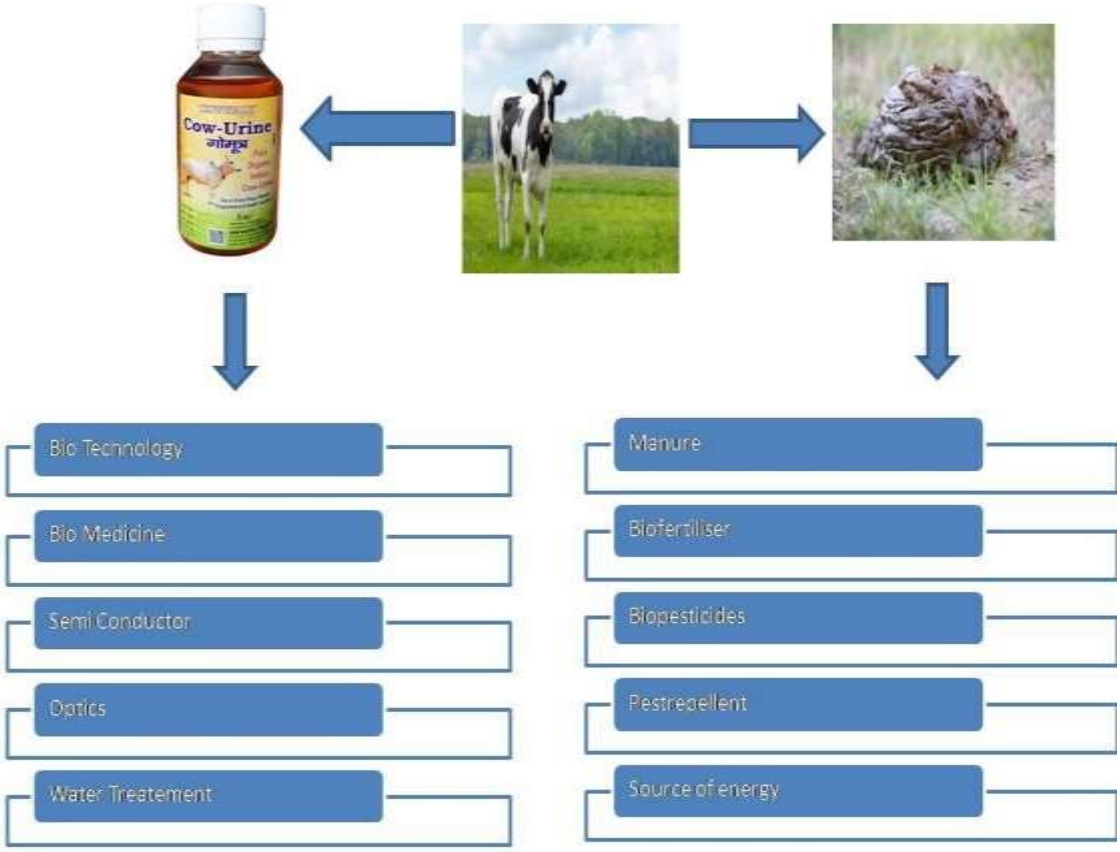

Fig 1: Applications of Cow urine and Cow dung

APPLICATIONS OF VERMIWASH MEDIATED NANOPARTICLES

Latha Rathinam et al.[2] have studied the potential of vermiwash to synthesize the silver and gold nanoparticles and evaluate its in vitro effect of antimicrobial and antidiabetic activities . The combined approach of nanobiotechnology using vermiwash was confirmed and characterized using various techniques.

Suganya Paulraj et al.[46] have investigated the biosynthesis of copper oxide nanoparticles (CuO NPs) by simple Co-precipitation method using Eudrilus eugeniae vermiwash and its applications to the seed germination of green gram (Vigna radiata).In order to evaluate the bio-potential properties of CuO NPs, a seed germination studies were carried out with green gram (V. radiata) with different concentrations of CuO NPs, and the result reveals that CuO NPs show a positive influence on the germination of green gram.

K. Ravichandran et al.[47] have synthesized Enzyme powered Mo doped TiO2 nano powder via a simple soft-chemical method using vermiwash exhibited remarkable photocatalytic efficiency and desirable biomedical properties. Results showed that incorporation of molybdenum (Mo6+) and inclusion of enzymes like amylase, phosphatase, protease and urease derived from the vermiwash resulted in an improvement in the photocatalytic, antibacterial, antioxidant and antidiabetic abilities of TiO2.

Suganya Paulraj et al.[48] have reported the biosynthesis of molybdenum oxide (Mo5O14) nanoparticles (NPs) by co-precipitation methods using various vermiculture-based extracts and their impact on seed germination in Vigna radiata

P Suganya et al.[49] have studied the biosynthesis and characterization of Zinc oxide (ZnO) nanoparticles and its influence on seed germination in the pulse crop, green gram (Vigna radiata). The ZnO nanoparticles (NPs) synthesized through the co-precipitation of Zinc acetate with sodium hydroxide vermiwash obtained from leaf litter compost of Earthworm, Eudrilus eugeniae.

K. Ravichandran et al.[50] have synthesized enzyme-activated zinc oxide nanomaterial using vermiwash via a simple soft chemical method. This vermiwash—an aqueous extract obtained from vermin reactor—is produced using earthworm, Eudrilus eugeniae, cow dung and leaf litter.

The prepared nanoproduct was used to decompose toxic dye molecules through photocatalysis.

Tanvi singh et al.[51] have studied vermicompost and vermiwash hold great potential as green pesticide for sustainable agriculture as well as environment improvement. This is a safe and effective way to meet the growing need of food due to increase in population. This technology requires promotion and training to the farmers so that efficient use of locally available material can be done in order to produce vermicompost.

Hudaverdi Arslan et al.[52] have used vermicomposting leachate to synthesize FeO-NPs. The highest DPPH activities of VCL-FeO-NPs at 200 mg/L concentration were 93.54%. In addition, the nanoparticle showed significant DNA nuclease activity. The antimicrobial activity of VCLFeO-NPs showed moderate antimicrobial activity against Gram positive, Gram negative, and fungi. However, the nanoparticles showed more effective microbial cell inhibition activity against E. coli. Also, biofilm inhibition results were detected against S. aureus and P. aeruginosa were 66.05% and 67.29%, respectively.

R.Shalini et al.[53] have studied synthesis of vermiwash activated molybdenum doped tin oxide (Mo:SnO2) nanomaterial, for the photocatalytic degradation of a representative cationic dye - methylene blue (MB). The photocatalytic performance of the synthesized nanoparticles was evaluated using UV-visible (UV-vis) spectroscopy and the degrading efficiency of MB dye was quantified. The addition of vermiwash resulted in a marked improvement in the photocatalytic activity of Mo:SnO2 nanoparticles, with a degradation efficiency of 96% achieved after 75 min of irradiation.

K. Ravishandran et al.[54] have reported enzyme-powered zinc oxide nanomaterial using vermiwash derived from the earthworm (Endrilus eugeniae) culturing unit. The results provide strong evidence to support the potential use of vermiwash for synthesizing nano-sized photocatalysts that can be used to treat toxic organic pollutants, such as methylene blue.

K. Ravichandran et al.[55] have synthesized Natural enzyme supported SnO2/gC3N4 nanocomposite using vermiwash, an aqueous liquid obtained from the excretes of earthworm. This nanocomposite acting as a photocatalyst decomposes both the cationic and anionic toxic dye molecules effectively. The photocatalytic dye degradation efficiency of enzyme supported SnO2/g-C3N4 nanocomposite was 96 % in 60 min, whereas those of bare SnO2 and g-C3N4 were 62 % and 76 %, respectively for the MB dye.

Riya et al.[56] have studied in organic farming, vermiwash, a liquid extract from vermicompost, is used as a growth promoter and biofertilizer to reduce a variety of stressors. Nevertheless, little is known about its capacity to mitigate salt stress in Brassicaceae crops, such as radish (Raphanus sativus L.) and turnip (Brassica rapa L.). This experiment investigated the protective effects of vermiwash on turnip cultivar (L-1) and radish cultivar (Pusa Chetki) under 100 mM NaCl salt stress.

P. Suganya et al.[57] have successfully prepared cubic and spherical structure of Fe NPs via coprecipitation method using seven different earthworm based extracts. These aqueous extracts of seven different earthworms based extracts were acted as potential reducing and stabilizing agents. The β-Fe2O3 nanoparticles appeared in different morphological structures and methods used in the present study are simple, efficient and non- toxic.

S. P. Singh et al.[58] have studied the biosynthesis or myco-synthesis of copper oxide nanoparticles using precipitation method. Trichoderma culture filtrate, Vermicompost extract and Copper sulphate was used as precursor.

S. Suvathi et al.[59] have prepared Enzyme-coupled titanium oxide nanopowder samples nusing different volumes of vermiwash using a cost-effective soft chemical method and their photocatalytic efficiency was studied against Methylene Blue (MB) dye decomposition.

Azim Nemati et al.[60] have reported the Gibberellins are plant growth hormones known for their role in plant development and stress responses, while vermiwash is a bio-fertilizer rich in nutrients and microbial agents. They applied gibberellin and vermiwash (GV treatment) to tomato plants and assessed the impact on P. *absoluta* developmental stages, reproduction and enzymatic activities. This study suggests that gibberellin and vermiwash treatments could be incorporated into pest management strategies for sustainable tomato production.

D.S.Vasanthi et al.[61] reported vermiwash derived—enzyme enriched ZnO NPs co-doped with copper and nitrogen were synthesized using soft chemical method for cost-effective and ecofriendly photocatalytic dye degradation.

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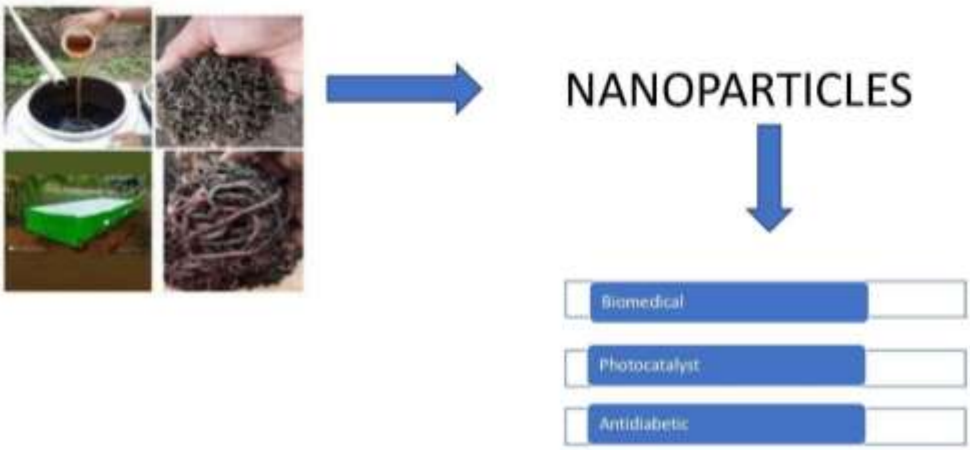

Fig 2: Applications of Vermiwash

CONCLUSION

This review study explored the current research scenario surrounding the biological synthesis of nanoparticles using cow dung as manure and cow pee as fuel, as well as a variety of potential uses. Expected synthesis pathways have been investigated, and a current literature review on the use of cow dung, cow urine and vermiwash synthesis has been conducted. In conclusion, future research should focus on transferring laboratory-based work to an industrial scale by taking into account contemporary risks, especially environmental effects and human health. However, biogenic nanoparticles syntheses based on biomolecules-assisted nanoparticles are predicted to be widely used in the biosensor, biomedical, pharmaceutical, textile, food, ceramics, and cosmetic sectors as well as in the field of ecosystem remediation. The field of green nanoparticles syntheses using cow dung, cow urine and vermiwash is yet substantially unexplored. As a result, there are still many opportunities for researching new biosynthetic-based green preparation methods.

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