From Waste to Wealth: A Comprehensive Review on Organic Fertilizers Derived from Plant and Animal Waste

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***Abstract*—With the global population growing rapidly, the need for food is increasing significantly. To meet the demand, farmers rely on the chemical fertilizers. However, despite their benefits, they have a negative impact on the environment, such as degrading soil health, reducing soil fertility and heavy metal accumulation. These concerns have sparked a growing interest in sustainable agricultural practices, particularly the use of organic fertilizers derived from natural sources. This review explores the potential benefits of organic fertilizer derived from animal waste (such as cow urine and dung) and plant waste like fruit peels. These materials help improve soil quality by adding essential micronutrients and reduces the ecological harm. Existing studies indicate that organic fertilizers not only support healthy plant growth but also contribute to effective waste management for long-term agricultural sustainability. This review underscores the need for further research and widespread adoption of organic fertilizers as a viable alternative to conventional practices.**

***Index Terms*—Organic fertilizers, waste management, cow urine, sustainability, fruit peels.**

I. INTRODUCTION

As the global population grows, the pressure to increase crop production intensifies hence, feeding the vast population is a significant task [1].To meet this demand, the use of chemical fertilizers, pesticides and insecticides have been used to produce crops with high yield within the shortest period of time and to protect them from pest and insect attack [2]. Synthetic fertilizers were first formed during the mid-19th century, they are beneficial in the short term but has serious longer-term side effects such as soil erosion, soil acidification and overall decline in soil fertility over time along with health concerns about toxic chemicals entering in food supply [3]. The concepts of "food security" and "food insecurity" are now frequently discussed in the context of global agricultural development. Food safety refers to the availability and accessibility of safe and nutritious food that meets the needs of individuals for a healthy and active life, on the other hand, food insecurity arises when there is a lack of reliable access to sufficient and nutritious food, affecting health and overall quality of life. Another key contributor is the massive use of synthetic fertilizers; several studies shows that these fertilizers caused hazard to public health and the environment [4] [5]. This review highlights the role of organic fertilizers made from animal and plant sources in crop improvement and the production of safe and secure food.

The crop yield significantly depends on the type of fertilizers applied to supply vital plant nutrients.

Figure 1 Types of fertilizers

1. Inorganic fertilizers are also known as synthetic fertilizers and they have an industrial origin and the major ingredients are nitrogen, phosphorus and potassium, hence they are also called as NPK fertilizers [6]. They are available easily at a low cost and give fast results however they are non-biodegradable [7].
2. Fertilizers derived from natural materials without industrial origin are termed as organic fertilizers. They are known to improve soil fertility and are sustainable. [8] They are known to give slow but steady and safe results [9].
3. Bio-based fertilizers also known as biofertilizers, they are composed of micro-organisms that support plant growth and enhance crop productivity. These fertilizers harness atmospheric nitrogen and provide it directly to the plant [10]. The most used biofertilizers are nitrogen-fixers, potassium-mobilizing microbes, and phosphorus-solubilizing organisms.

Impact of inorganic fertilizers on the environment and human health

Application of inorganic fertilizers can stimulate the production of greenhouse gases like methane. Nitrogen fertilizers can also inhibit methane-oxidizing bacteria, which normally consume methane and convert it into carbon dioxide, this leads to higher methane emissions [11]. When inorganic fertilizers are used in agricultural land, they can be converted to nitrous oxide by soil microorganisms. N_2O is a potent greenhouse gas, and its emissions from agricultural land is the major contributor to global warming [12]. The prolonged use of chemical fertilizers changes the soil pH due to the nitrification process and upset the beneficial microbial ecosystem. This process can lead to a decline in soil fertility and decline crop yield over time [13].

Excessive, improper or uncontrolled use of urea fertilizers can lead to serious health problems such as respiratory problems and male infertility. The reason for this is the presence of biuret, a toxic compound that becomes more active at high temperature. Also, urea releases ammonia gas as it decomposes which can contribute to health hazards. Similarly, long-term use of phosphate-based fertilizers results in the accumulation of toxic heavy metals in the soil, most commonly, cadmium, this can enter in the food chain through crops or livestock and pose a significant risk to human health, which includes organ damage and toxicity [18].

The use of cow urine as a liquid organic fertilizer

The application of organic manure not only supports crop production but also significantly improves the nutrient availability in the soil, it does so by positively impacting the soil's physical, chemical, and biological characteristics.

Livestock has been one of humanity's most valuable resources in farming systems, integrating cattle into agricultural practices remains the most practical approach, farm generate large amount of cattle waste (dung and urine), while decomposed dung is commonly used as fertilizer, cow urine is often discarded as waste. However, cow urine is a rich, natural source of essential nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, chloride and sulphate. It offers a cost-free and sustainable nutrient solution for farmers, when used in agriculture, it poses no harm to the nature.

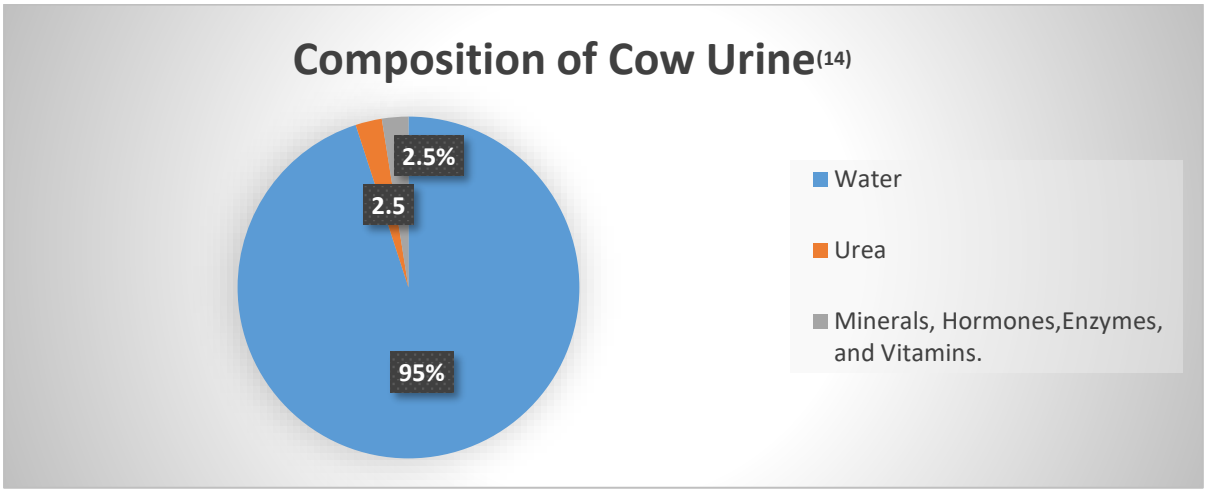

Figure 1: Composition of cow urine

Effect of cow urine on vegetable crops

A study conducted by Jandaik et al. (2015) evaluated the influence of various concentrations of cow urine (1%, 2%, 3%, 4% and 5% v/v) on two most cultivated vegetables, *Abelmoschus esculentus* (okra) and *Trigonella foenum* (fenugreek). The results show a progressive increase in total chlorophyll content with respect to increasing concentration of cow urine, 5% concentration shows the most significant enhancement, in fenugreek the total chlorophyll content was approximately 0.972mg/g compared to 0.5mg/g in the control group. Similarly, in okra, 5% cow urine treatment has 2.246mg/g and the control has 0.171 mg/g. These finding suggest that cow urine is rich in essential nutrients such as nitrogen, potassium, and trace elements, it plays a vital role in enhancing photosynthetic and metabolic activity, leading to improved growth and nutritional composition of vegetable crops, this study supports the broader application of cow urine as a low-cost, sustainable alternative to the chemical fertilizers [15].

Effect of cow urine on soil properties

Cow urine application has been reported to improve soil structure and texture along with its chemical properties. According to Aguilera et al. (2010), the use of high doses of liquid cow manure has increased soil pH, electrical conductivity (EC), nutrient availability, and dissolved organic carbon (DOC) content. These changes collectively contributed to better soil structure and tilth, which are vital for aeration, root penetration, and moisture retention. The microbial load in cow-based liquid manure stimulates microbial biomass and enzymatic activity, which aids recycling of nutrients and improves the biological health of soil. Thus, cow urine and its derivatives are not only act as a nutrient source but also as soil conditioners making them valuable components in a sustainable farming system [16]

Cow urine in pest control strategies

Cow urine has shown potential in pest management, though it is rarely used as a standalone biopesticide, because its pesticidal activity is generally limited when applied alone, however, when used in combination with plant-based extracts like neem extracts, garlic or turmeric it shows synergistic effect. According to Gahukar (2013), cow urine formulations act as a synergistic agent that significantly enhances pest mortality rates against a range of agricultural pests, this suggest that cow urine is more effective as an additive or enhancer in integrated pest management system, where it contributes to increased efficacy, sustainability and cost effectiveness of organic pest control strategies [17].

Fruit peels and its potential to be used as organic fertilizer

A large amount of fruit waste is generated in the food industry level and household level. Major wastes are fruit peels and their seeds [19]. Fruit peels are very rich in micro and macro nutrients that are essential for plant growth, fruit peels are good source of nutrient like potash, calcium, iron, zinc. etc [20]. A study reported by Jariwala and Syed (2016), examined the efficacy of fruit peel powder as an organic fertilizer on okra, they prepared fruit peel powder from various fruits such as, banana, pomegranate, and orange peel. And applied them to soil and evaluated their effects on plant growth. The results clearly indicated that the incorporation of fruit peel powders significantly enhanced plant growth when compared to the control. Parameters that were observed during the study are plant height, leaf area, root length, chlorophyll content, flowering time, and flower weight and total yield. Study showed notable improvement across all treatments, but combination of banana and orange peel powder demonstrated the most superior results [19].

The study conducted by Mercy et al (2014) evaluated the use of banana, pomegranate, orange, and sweet lime peels as natural fertilizers. These fruit peel formulations are applied in both liquid form and powder forms on fenugreek, plant growth observed after 45 days, the results shows that growth and yield were significantly improved, NPK content were improved, such as N rose from 2.3mg/g control to 4.7mg/g, P rose from 2.4mg/g to 3,5mg/g and K rose from 1.2mg/g to 2.1mg/g[21].

These finding support the practical use of fruit peel waste as a potential organic supplement to reduce reliance on synthetic/chemical fertilizers, thereby offering a sustainable and environmentally friendly approach.

Study on eggshell and fruit peels as an organic fertilizer

The study conducted by Khairnar and Nair (2019) investigates the use of household organic waste namely eggshells, and fruit peels like banana and sweet lime peels as natural fertilizer. Recognizing the negative impacts of long-term use of chemical

fertilizers on soil health, the research focuses on cost-effective and sustainable alternatives to enrich soil with essential nutrients. Eggshells are rich source of calcium, which is crucial for plant cell wall formation

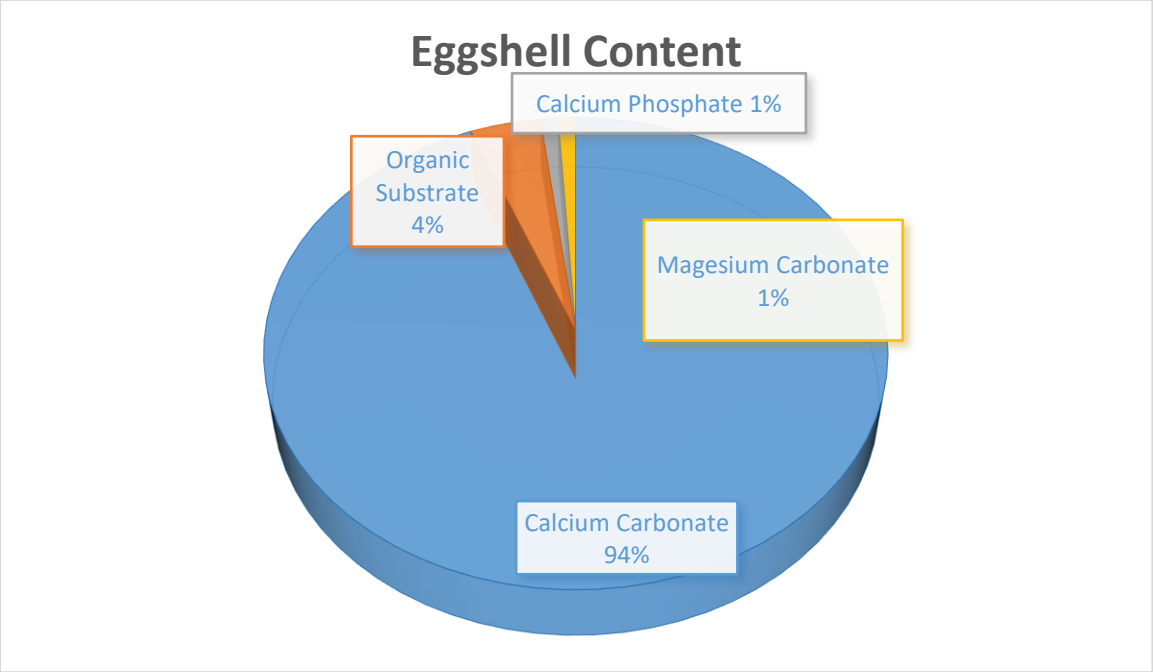

Figure 2 composition of eggshells (23).

and root development, while fruit peels provide essential vital micro and macro nutrients. The study successfully demonstrates that these organic wastes can be effectively utilized as organic fertilizer, each of these components plays a vital role in enhancing soil fertility and supporting plant growth. This study promotes sustainable waste management by converting biodegradable waste into valuable organic products. Therefore, this approach offers a promising effective alternative to chemical fertilizers [22].

II. FUTURE PROSPECTS

Future research should focus on the preparation and standardization of the organic fertilizer formulations derived from various waste sources and optimization to ensure consistent and reliable results across different crop types and soil conditions. Also, there is a strong need to promote awareness and training among the farmers regarding the preparation and benefits of these organic fertilizers. Future research should explore the synergy between the cow urine and other organic waste to develop integrated nutrient strategies that promote higher yields and sustainability. Also, there is a need for long-term studies to fully understand their benefits and cumulative impact on soil health, crop yield, and environment sustainability.

III. CONCLUSION

The growing environmental concerns and health risk associated with the long-term use of chemical fertilizers have highlighted the need for organic sustainable alternatives in agriculture. Organic fertilizers derived from animal and plant waste such as cow urine, cow dung, fruit peels, eggshells, offers a promising, sustainable and powerful solution. These organic fertilizers not only support plant growth but also enhance soil fertility and improve microbial activity. These practices support sustainable waste management. Combination of both animal waste and plant waste into an organic fertilizer depicts the changes resulting into the solution for increasing global food demand by improving crop yields, soil quality, and environmental health. With the continuous research and implementation, this method offers a eco-friendly path to achieving more sustainable agriculture while minimizing harmful impacts of chemical fertilizers.

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