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Synergistic Enrichment: Unveiling the Chemistry Behind a Formulated Green Organic Fertilizer for Sustainable Soil Enhancement

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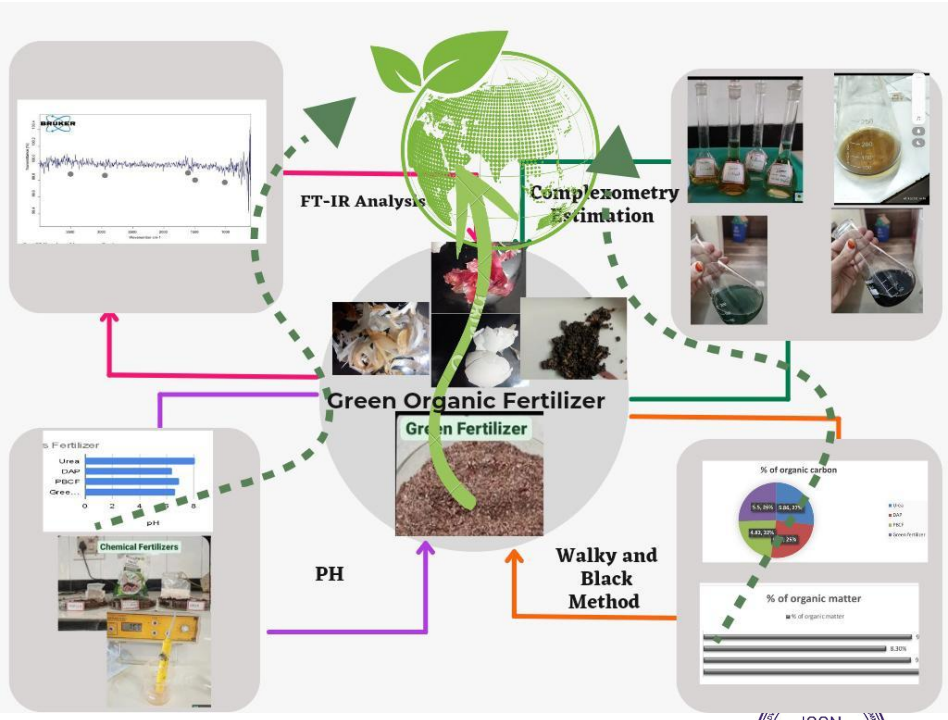
Abstract: *This research focuses on the global challenge of increasing crop production sustainably, emphasizing the environmental impact of excessive fertilizer use. In this research we introducing a novel green organic fertilizer prepare from Allium cepa (Onion)and Allium sativum (Garlic) peels, Camellia sinensis (Tea) leaves waste, and eggshell. The study employs methods like complexometric titration and FT-IR spectroscopy to highlight its nutrient-rich composition and positive impact on soil quality. The study revealed the potential of Green organic Fertilizer to improve the balanced soil, maintain the optimal pH, and significantly increase organic matter and carbon content. The study advocates its integration into traditional farming practices and presents it as a flexible and sustainable method of promoting healthy soils rich in nutrients. The fusion of essential metal ions and organic components in this fertilizer provides a holistic approach to soil enrichment and promises a greener and more productive agricultural future.*

Graphical abstract:



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Keywords: Green Organic fertilizer, comparative estimation of green fertilizer with chemical fertilizers, organic content in soil, complexometric estimation

I. INTRODUCTION

The population of the people continues to grow, the increase in crop production without causing disruption to the environment is the main challenge facing agriculture today[1][2]. Increased crop productivity remains the most feasible way to meet the major challenge of supplying 9.8 billion people by 2050 [3]. In order to increase soil fertility, fertilizers are used as a source of plant nutrients. The increase in soil fertility through the application of fertilizers is the common method of modern agricultural practice [4][5].Fertilizer is a natural or artificial substance that contains chemical elements that increase the growth and productivity of plants. Increase soil fertility or replace chemical elements extracted from the soil by previous crops[6].Economic and population growth are the main drivers of increased fertilizer consumption. Estimated production of chemical fertilizers in India during since last year shown below (Fig 1. Production in Lack metric tones).

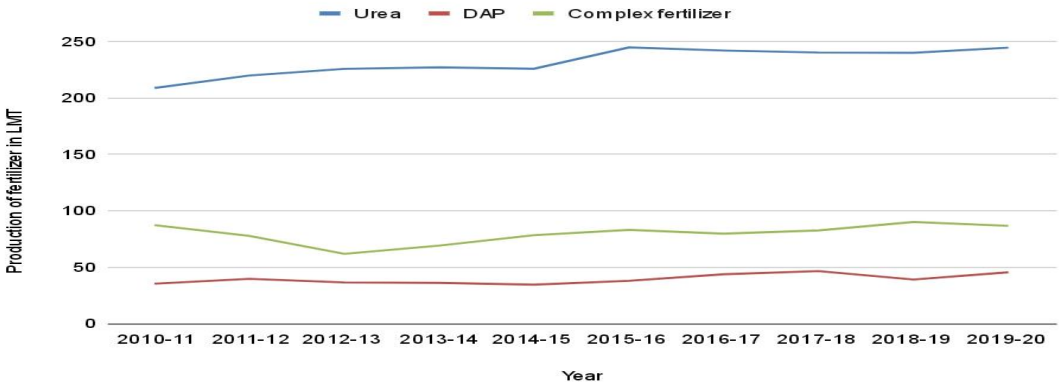

Fig 1: estimated production of fertilizer in india during past 10 years
(sources : mfms.nic.in)

As per Figure 1:The data indicates a consistent rise in Urea usage from 2010-11 to 2019-20, with peaks in 2015-16 and 2019-20. DAP shows fluctuations without a clear trend, reaching a peak in 2017-18. Complex fertilizer usage declines initially, then rises until 2018-19. Consider external factors influencing these trends for a comprehensive analysis.Overr the next few years, fertilizer demand in mature markets such as europe and north america is expected to remain fairly stable. Meanwhile, latin america and asia are expected to drive global fertilizer demand. In general, global fertilizer demand is expected to reach 208 million tons of nutrients by 2026, and in 2021 the global fertilizer market will reach more than 193 billion us dollars, an increase of about 12 percent compared to the previous year. The market for fertilizers is expected to exceed us$240 billion by 2030[7], along with the increase in the cost-effectiveness of fertilizers, it also contains toxic chemicals absorbed into plants, and the toxins entered the food chain through vegetables, cereals, and water, which caused serious health problems[8]. However, overuse of fertilizers can lead to some problems such as soil nutrients loss, surface water pollution and groundwater pollution, soil acidification and sludge, and reduced useful microorganisms [2][9][10][11]. Overuse harms soils, reduces fertility, strengthens pesticides, pollutes air and water, releases greenhouse gases and exposes people to dangers and posed health and environmental threats. Chemical fertilizers used in crops may have a harmful effect on waterways as a result of excessive chemical emissions of fertilizers. The abundance of nutrients in the water reduces oxygen intake. As a result, the depletion of oxygen causes the deaths of fish. The excess chemical fertilizer used in crop contributes to greenhouse gases such as carbon dioxide and nitrogen oxides. Excessive use of chemical fertilizers leads to soil acidification due to reduced soil organic matter. Over time, large amounts of nitrogen applied to the soil damage the soil and reduce crop yields. Excessively large amounts of synthetic fertilizers have harmful effects on human health. High concentrations of nitrates and nitrites in chemical fertilizers cause cancer, hemoglobin disorders, and Alzheimer's disease. However, the repeated and excessive use of chemical fertilizers has also resulted in a reduction in crop yields and soil fertility. As a

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result, current agricultural trends have placed an emphasis on the search for alternatives to non-renewable chemical fertilizers, which are subject to enormous procurement costs and environmental pollution. Organic fertilizers include mud, animal waste, plant waste from agriculture. As waste from plants such as onions, garlic, tea leaves, eggshells are an efficient source of basic nutrients such as nitrogen, phosphorus, potassium, and secondary and micronutrients such as calcium, boron, magnesium, and manganese. Organic fertilizers are mainly affordable and easy to obtain from local products. In this work, the peels of dried onion, garlic, tea leaves and eggshells were mixed to prepare organic fertilizers[14][15].We select this four kitchen waste for formation of Green organic fertilizer because (a) Onion peel rich in phenols, flavonoids and flavanols, anthocyanin ,tannin, vanillicacid which play key role in plant growth [16][17][18][19].(b)Garlic peel contain, sorbitol, and trehalose, 5-hydroxylysine, rhamnose and mannitol which enhances increases soil enzymatic activity by improving the environmental and nutritional conditions of the soil microorganisms[20].(c)While Tea leave waste contain Cellulose,Lipid , Polyphenols etc and (d)Egg shell constitue high amount of Calcium .The novelty of this research lies in its innovative approach to developing a green organic fertilizer using readily available kitchen waste materials. By combining onion and garlic peels, tea leaves, and eggshells in specific proportions, the study proposes a novel formulation that harnesses the nutrient-rich properties of these organic sources. Additionally, the research employs advanced analytical techniques such as complexometric titration and FT-IR spectroscopy to characterize the fertilizer's nutrient composition and assess its impact on soil quality. Furthermore, the study examines the fertilizer's effectiveness in maintaining balanced soil pH, increasing organic matter and carbon content, and enriching soil with essential metal ions like magnesium, zinc, calcium, iron, and cobalt. Overall, the integration of these diverse organic materials and the comprehensive evaluation of the fertilizer's properties and performance represent the novelty of this research.The synergistic combination of organic waste materials in the green organic fertilizer will result in a sustainable and environmentally friendly solution for agricultural soil management.

II. MATERIALS AND METHODS

2.1. Materials

Urea, DAP(Diammonium phosphate fertilizer),Phosphate base chemical fertilizer(PBCF), formulated green organic fertilizer ,conc.H2SO4,Sodium salt of EDTA(Loba), $KMnO_4$ (Loba),$K_2Cr_2O_7$, 0.5 M(NH4)2Fe(SO4)2.6H2O, H_3PO_4,Buffer pH 10,Xylenol indicator, Erichrome black T indicator, Diphenyl amine ,All other chemicals and solvents were of reagent grade.

2.2. Methods

2.2.1.Instruments.

The pH was measured by using a pH meter (EQ 610), Fourier Transform Infrared spectrophotometer (FTIR) instrument. All physiochemical measurements were performed at room temperature 25± 20 C. 0.25 g soil (soil mixed with Fertilizer) take 50 ml distilled water stir it well and stand it for 30 minutes and note pH

2.2.2.Formulation of green organic fertilizer

Dried powder of Allium sativum peel: Allium cepa peel: Camellia sinensis leave waste:Egg shellwas mixed in 1:3:3:1 ratio and organic fertilizer formed.

2.2.3. Preparation of stock solution.

To 0.5gm of powdered organic fertilizer added 0.1 cm^3 conc.H2SO4 until it dissolves further dilute using (10ml) distilled water and heated gently till it maximum dissolve and filter it through filter paper in volumetric flask and dilute up to the mark this is stock solution which is prepared for all samples.

2.2.4 .Estimation of essential metal ions in green organic fertilizer

Metal ion was analysed by complexometric titration using 0.2 M EDTA against 10 cm3 of stock solution using suitable indicator.

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Sample	Elements	Percentage	Name of indicator
Onion peel	Magnesium	2.72%	Erichrome black T
	Iron	5.4%	Diphenylamine
	Zinc	5.2%	Erichrome black T
Garlic peel	Magnesium	3.2%	Erichrome black T
	Zinc	16%	Erichrome black T
Tea leaves	Cobalt	14%	Xylenol
	Zinc	5%	Erichrome black T
Egg shell	Calcium	36%	Internal indicator

Table 2: Essential metal ion found in formulated green organic fertilizer.

These all ions are play very important role in fertility of soil and in growth of plants. Other ion that is sulphate , nitrate traces of phosphate were also found.

2.2.5.Determination of organic Carbon and Organic content in a soil sample

Estimation of organic carbon and organic content using Walky and Black method[21][22]. Taking 2g of Urea, DAP (Diammonium phosphate fertilizer), phosphate base chemical fertilizer and green organic fertilizer in 4 different Petridis and adding 25g soil per dish.

2.2.6.FT-IR Analysis of Green organic fertilizer.

FTIR analysis was performed using a [make and model of the FTIR instrument].The FTIR scans were conducted in the spectral range of 4000 cm-1 to 400 cm-1 .

2.3. Theoretical background

From the equation:

$$2\ Cr_2O_7^{2-} + 3\ CO + 16\ H^+ \leftrightarrow 4\ Cr^{3+} + 3\ CO_2 + 8\ H_2O$$

1 mL of 1 N dichromate solution is equivalent to 3 mg of carbon

After the reaction, the excess Cr2O7 is titrated with 0.5 M FeSO4 or 0.5 M (NH4)2 Fe(SO4)2.6H2O

$$6\ Fe^{2+} + Cr_2O_7^{2-} + 14\ H^+ \leftrightarrow 2\ Cr^{3+} + 6\ Fe^{3+} + 7\ H_2O$$

$OrganicC, \% = (V_{blank} - V_{sample}) \times MFe^{2+} \times 0.003 \times 100 \times f/W$

where:

V_{blank} = volume of titrant in blank, mL

V_{sample} = volume of titrant in sample, mL

MFe^{2+} = concentration of standardized FeSO4 or (NH4)2 Fe(SO4)2.6H2Osolution, molarity

0.003 = carbon oxidised

f = correction factor, 1.3

W = weight of soil, gm

III. RESULTS AND DISCUSSION

Essential metal ion in formulated green fertilizer from complexometric estimation using EDTA (0.2M) Magnesium, Zinc, Calcium, Iron, Cobalt was found(Table2).

3.1. PH of soil sample after addition of various fertilizer

The pH analysis after introducing various fertilizers reveals urea's alkaline influence at 8.1, DAP acidic contribution at 6.4, and the formulated green fertilizer maintaining a slightly acidic pH at 6.6, showcasing its potential for balanced soil enhancement. We get following result as shown in Fig 2.

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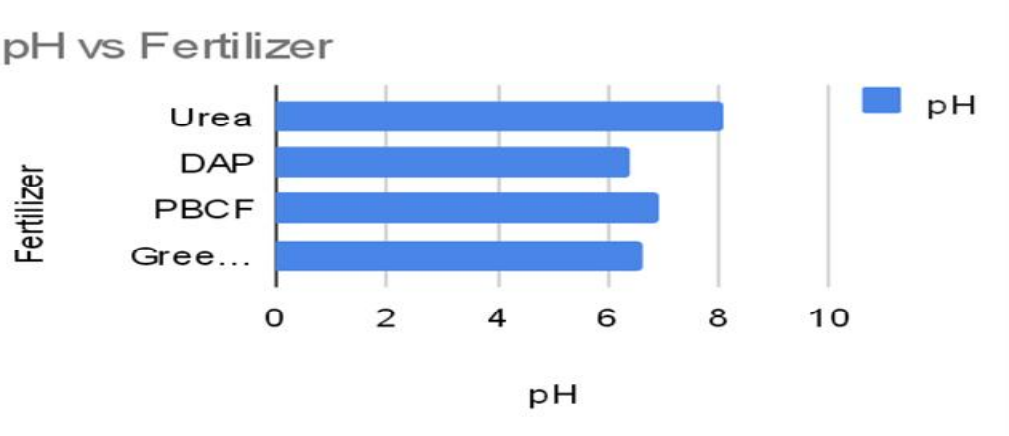

Fig 2: pH of soil containing different fertilizer.

3.2. Determination of organic Carbon and Organic content in a soil sample.

The research explores the synergistic impact of a formulated green fertilizer rich in essential by to metal ions—magnesium, zinc, calcium, iron, and cobalt—on soil quality. Delving deeper, the investigation into organic matter and carbon content illustrates the green fertilizer's positive influence. It stands out with a commendable 9.47% organic matter and 26% organic carbon, underlining its role in fostering a fertile and nutrient-rich soil environment. Result represented by Fig 3(a) and 3(b).

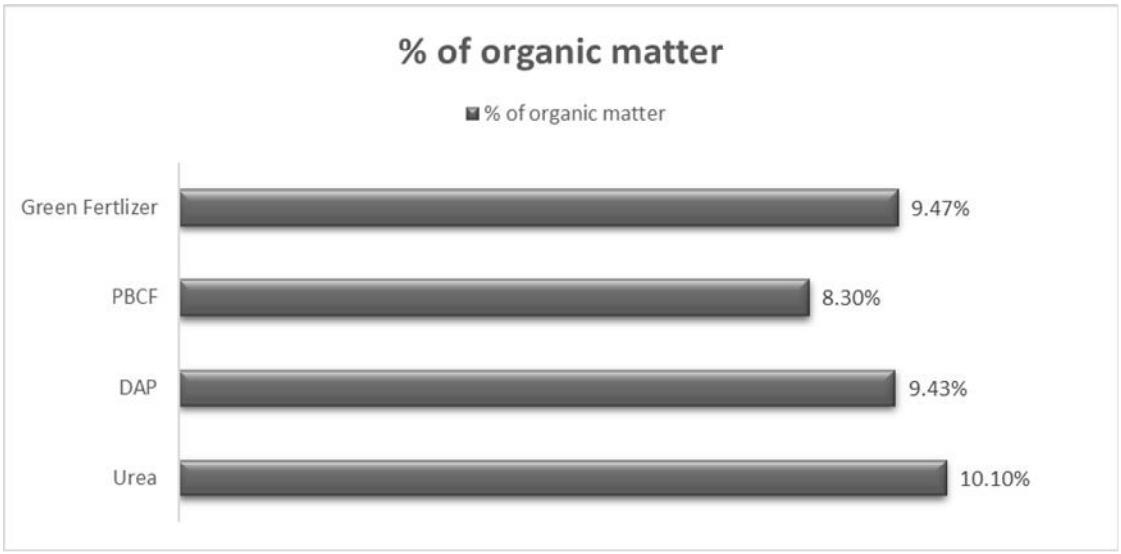

Fig 3(a): Organic matter in soil containing different fertilizer

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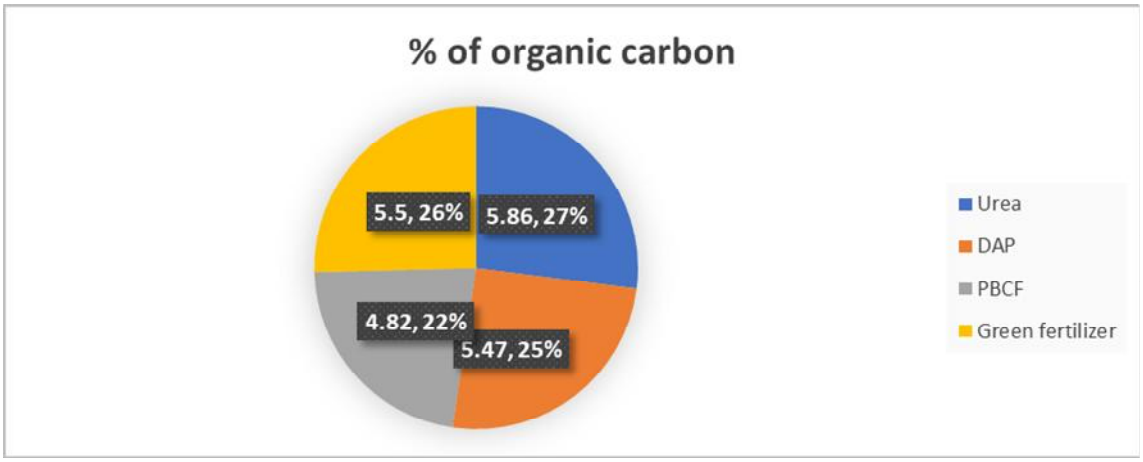

Fig 3(b): Organic Carbon in soil containing different fertilizer

3.3.FT-IR Analysis.

FTIR plot show peak at 1100cm-1 which indicates presence of C-O stretching frequency ,Peak at 1600cm-1 suggest C=C. stretching vibration ,Peak at 1700 cm-1 associate with C=O stretching vibration indicates yof carbonyl group. The peak at 2950 cm^{-1} corresponds to C-H stretching vibrations, indicating the presence of aliphatic hydrocarbons, which could be present in eggshells. Peak at 3520 cm-1 related to O-H stretching vibration .FTIR analysis attributed a various composition in the fertilizer, which includes aromatic compounds, carbonyl groups, aliphatic hydrocarbons, and hydroxyl groups, derived from the particular organic sources.

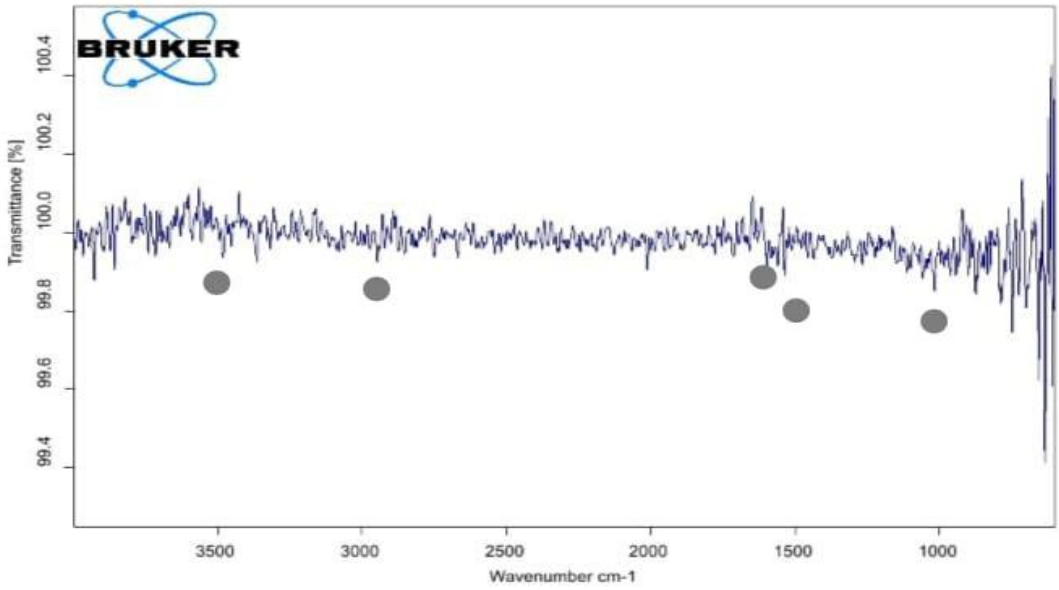

Fig 4.FT-IR analysis of Green organic Fertilizer

These findings not only underscore the significance of the formulated Green organic Fertilizer but also open door for sustainable agricultural practices, promoting both metal nutrient enrichment and organic content in soils.

IV. CONCLUSION

This research highlights the efficacy of the formulated Green Organic Fertilizer, whose core metal ions play essential role for soil quality. The complexometric titration and FT-IR analysis unveiled its nutrient-rich composition and

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molecular insights. The Green organic Fertilizer have a balanced pH, shows its potential to create an optimal environment for plant growth. However, percentage of organic matter and carbon in soil treated with green fertilizer show their ability to improve soil fertility. Its ability in promoting healthy plant growth places it as a valuable and eco-friendly resource for modern agriculture. Further studies and field trials are important to validate its impact and integrate it into mainstream farming practices, paving the way for a greener and more productive future. These conclusions suggest that the formed Green organic Fertilizer could work as a flexible and sustainable method for promoting healthy and nutritional rich soils in agricultural field. The combination of essential metal ions and organic components presents a holistic approach to soil enrichment, combining to success Environmental friendly and productive farm practices

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Declaration of competing interest. The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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