IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

BIOLOGICAL BREAKDOWN OF A FACEMASK WITH ACTIVE VERMIN'S AND BIOACTIVE PRINCIPLES OF MEDICINAL PLANT *LAGERSTROEMIA SPECIOSA* (L.) PERS

[1] Priyadharshini. P, [2]Ganesan. G, and [3]*Dr. P. S. Sujatha

[1]PG Student, PG and Research Department of Zoology, Government Arts College (Autonomous), Coimbatore - 641 018, Tamil Nadu, India
[2]Ph.D Research Scholar, PG and Research Department of Zoology, Government Arts College (Autonomous), Coimbatore - 641 018, Tamil Nadu, India
3*Associate Professor, PG and Research Department of Zoology, Government Arts College (Autonomous), Coimbatore - 641 018, Tamil Nadu, India

Abstract: The COVID-19 pandemic has led to an unparalleled surge in plastic pollution. COVID masks prevent droplets from contaminating the infected person as they cough, sneeze, or breathe in. As long as extremely transmissible COVID-19 mutations like Omicron grow in number, masks will remain an essential safety measure in certain situations. Medicinal Plants contain high amounts of specific minerals that are used to enrich the fertility of the soil. The aim of the study is to identify the biological breakdown of a face mask with active vermin's and bioactive principles of medicinal plant *L. speciosa*. The experiment was designed into 5 trials. The control is T1, which consists of yard soil (CT); the kitchen waste (KWCO) along with compost bedding materials is placed in T2. Likewise, T3 (KWCU) contains mask bits with trash. The substrates for vermicomposting were prepared by mixing 250 g of *L. speciosa* in the two types of trials: T4 consisted of an experimental plant mixed with compost bedding material (LSCO), and T5 consisted of an experimental plant mixed with an experimental sample (LSCU) along with compost bedding materials. From the trials Zn, Copper, Manganese and Iron were analysed. The level of zinc is higher amount in Sample C -49.9±1.015 and very trace amount in Sample D -15.7±0.61, The Sample E shows 46.8±0.529 Mn and lowest Sample B -40.3±0.7, The amount of copper in Sample E -21.3±0.92 and lowest in Sample B shows -12.8±0.52, and The Sample A shows highest amount of Fe -217.9± 0.36 and lowest in Sample C -125.4±0.61. The initial stage of each sample weight is 7 kg and the final weight of the sample is lower compare to the Initial weight. The current study discovered that kitchen waste, soy bean meal maker, unused face mask parts, *L. speciosa* dry leaves, and cow manure can be effectively transformed into vermicompost using earthworms. However, unused face mask bits should be blended with the proper amount of bulking material; otherwise, earthworm development and fecundity may suffer. Vermicompost included more NPK and secondary nutrients than feedstocks, but had less TOC and a lower C: N ratio.

Index Terms – Vermin's, Face Masks, *Lagerstroemia speciosa*, Compost, Earthworms, Zinc, Copper, Manganese, Iron.

I. INTRODUCTION

The health of humans and the environment may be at risk due to the rise in soil contamination over the past few decades. Human activity is the primary cause of soil pollution, as it leads to the build-up of toxins in soils that might potentially reach dangerous levels. A vast range of contaminants, both organic and inorganic, can be found in soil and can be caused by both naturally occurring substances and activities connected to human activity (Thamas *et al.*, 2023). The absence of clearly defined monitoring factors and indicators may make soil quality monitoring a challenging undertaking. Global population increase is straining soil fertility and quality, leading to soil pollution. Major causes include waste disposal, mining, agrochemicals, industry, and atmospheric deposition, with essential elements explained (De *et al.*, 2003).

COVID masks prevent droplets from contaminating the infected person as they cough, sneeze, or breathe in. As long as extremely transmissible COVID-19 mutations like Omicron grow in number, masks will remain an essential safety measure in certain situations (Javed *et al.*, 2020). On November 26, 2021, variation B.1.1.529 of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was classified as a variant of concern by the World Health Organization (WHO) and called "Omicron." Many changes that allowed the virus to grow worldwide and elude immune systems were blamed for it.

The epidemic has made handling hazardous medical waste and urban solid garbage extremely challenging. Face masks from hospitals and other mixed waste are gathered, and then taken to landfills and incinerators (Sarawut *et al.*, 2020). Therefore, municipalities responsible for waste collection and treatment should create guidelines and procedures to be applied during pandemics, and these guidelines should include waste reduction recommendations, protective measures, collection frequency, and end-of-life management of masks.

Earthworms are important detritus feeders that are crucial to soil metabolism and the breakdown of organic materials. They are known as soil health indicators (Ansari and Ismail, 2012). *Eisenia fetida* is the species who support the tropical climatic conditions. It is an epigenic earthworm living on the upper surface of soils feeding mainly on plant litter and other organic debris available on the soil surface (Vodounnou *et al.*, 2016). As these earthworms can consume a variety of organic matter, they are most suitable for converting organic wastes into useful organic manures (Chattopadhyay, 2012). The breakdown of organic materials by the combined activity of microbes and earthworms produces vermicompost, naturally occurring manure that is safe for the environment. It has a prominent porosity, high rate of decomposition, good aeration, effective drainage, large water-holding capacity, and elevated microbial activity. It looks like peat. According to Sanandaji *et al.*, (2024), this biological fertilizer is remarkable for its exceptional ability to retain water, which lowers crop water requirements by approximately 30-40%. The earthworms are used through the waste recycling organics urban, industrial and agricultural (Reinecke *et al.*, 1992).

Medicinal Plants contain high amounts of specific minerals that are used to enrich the fertility of the soil. Waste materials of medicinal plants help to increase the specific mineral content. The plants used were neem cake, citrus lemon (Dawoud and Eweis, 2006), eucalyptus, and lemon grass (Khair and Hafez, 2006). These medicinal plants contain many substances as antibiotics, antiseptics, phenolic compounds, alkaloids (Bhonde *et al.*, 1999), tannins, volatile oils, triterpenoids (Johnson *et al.*, 1996). The ornamental and medicinal plant is commonly known as crape myrtle. *Lagerstroemia speciosa* comes under the family Lythraceae. It is popularly known as Poomaruthu and is native to Southeast Asia, but has been introduced to many other parts of the world due to its attractive flowers and usefulness in traditional medicine.

The aim of the study is to identify the biological breakdown of a face mask with active vermin's and bioactive principles of medicinal plant *L. speciosa*.

II. MATERIALS AND METHODS

2.1 The collection and identification of the experimental plant

The leaves of *L. speciosa* were collected from the PG Girls Hostel, Government Arts College (Autonomous), Coimbatore District, Tamil Nadu, India. The identification and authentication of *L. speciosa* are done by the Botanical Survey of India, Coimbatore, and the voucher specimens numbered BSI/ SRC/ 5/23/2020/ Tech/ 50 were placed in the Department of Zoology, Government Arts College (Autonomous), Coimbatore.

2.2 Processing of Experimental Plant

L. speciosa leaves were collected, washed, and shadow-dried for 2 weeks. The leaves were ground to powder (100g) and soaked in ethanol (1000 ml). The powder was solubilized and mixed well with intermittent stirring for 4 days. After that, the extract was filtered using Whatman No. 1 filter paper and kept in a plastic tray to dry at room temperature (Kongathip, 1994).

2.3 Collection of Kitchen Waste

Kitchen waste is mainly plant-based, organic in nature, and decomposes quickly. Management of kitchen waste reduces or eliminates adverse impacts on land and converts it into organic fertilizer. Kitchen waste was collected from the girl's hostel and college canteen, Government Arts College, Coimbatore-18. The collected kitchen wastes dried in direct sunlight for three days and were prepared for composting. The total trash weight was 7kg per trial.

2.4 Pre-composting of Experimental Sample

The experimental sample was taken into two types of unused facemask. The total weight of the mask bits is around 250 g. For simple composting the masks cut into small pieces and then soak into the plain water for 24 hours. The soaked mask bits are mixed with bio mineralizer. This was allowed for pre-composting for 40 days. The partially composed mask bits were used in T3 and T4.

2.5 The Collection of Bedding Materials

For composting purpose, the collection of coir pith, cow dung and yard soil are used as a bedding material.

2.6 Rice Wash Water

Rice wash water can be beneficial for composting because it contains minerals and nutrients. Fermenting the rice water can also help to promote healthy bacterial growth in the compost.

2.7 Experimental Animal

Earthworms are considered as natural bioreactors which proliferate along with other microorganisms and provide required conditions for the biodegradation of waste. The earthworm *Eisenia fetida* was purchased from the Vermigold organics (ESTD. 2004) (G5GC+W63) Aanaimalai – Dhali Road, Udumalpet, Tamil Nadu 642132, India. The *E. fetida* is commonly called red wriggler or red worm. The *E. fetida* is a well-adapted, short-life span species with a high reproduction rate.

As with other earthworm species, *E. fetida* is hermaphroditic, and uniparental reproduction is possible, even if usually the reproduction is between copulating individuals. The two worms join clitella, the large, lighter-coloured bands which contain the worms' reproductive organs, and which are only prominent during the reproduction process. The two worms exchange sperm. Both worms then secrete cocoons, which contain several eggs each. These cocoons are lemon-shaped and are pale yellow at first, becoming more brownish as the worms inside become mature. These cocoons are clearly visible to the naked eye. At 25°C, *E. fetida* hatches from its cocoon in about 3 weeks. The lifespan of *E. fetida* under controlled conditions varies between one and five years. The red worm is reddish-brown in colour, has small rings around its body, and has a yellowish tail. Groups of bristles (called setae) on each segment of the worm move in and out to grip nearby surfaces as it stretches and contracts its muscles to push itself forward or backward. *E. fetida* worms are native to Europe.

2.8 Experimental Design

The control is T1, which consists of yard soil (CT); and the kitchen waste (KWCO) along with compost bedding materials is placed in T2. Likewise, T3 (KWCU) contains mask bits with trash. The substrates for vermicomposting were prepared by mixing 250 g of *L. speciosa* in the two types of trials: T4 consisted of an experimental plant mixed with compost bedding material (LSCO), and T5 consisted of an experimental plant mixed with an experimental sample (LSCU) along with compost bedding materials. The rice wash water is used to maintain the moisture content of the substrate at 60–65% for a period to facilitate the preliminary decomposition of materials.

After an undisturbed observation period of 7 days to test the mortality rate of the experimental animal before the composting period, the content in the replicates was mixed and the moisture content was checked together with the earthworm's activity. After that period, 25 adult worms were added to each trial. All the experimental setup was carried out at the P.G. & Research Toxicology Lab, Department of Zoology, Government Arts College, Coimbatore. The total experimental period was 90 days.

Figure 1 Experimental Design of Different Trials

2.9 Parameters

Vermicompost was produced by the earthworm (*E. fetida*) processing fresh household waste continuous, long-term decomposting process (3 months) in a plastic composter. Vermicompost was obtained from five different samples of the upper part, free from earthworm, and it is commonly used for preparation of soil sample for analysis. Soil without vermicompost was used as the control. The important secondary metabolites Zn, Cu, Mn and Fe were determined.

2.9.1 Determination of Zinc (Zn)

Zinc can be detected by dissolving the substance in hydrochloric or nitric acid, boiling, adding sodic hydrate in excess, filtering, and adding ammonic sulphide to the filtrate (Broadley *et al*., 2007).

2.9.2 Determination Copper (Cu)

In order to determine the content of copper in the soil, 10 cm of the solution obtained after mineralization of samples were transferred to separatory funnel, all reagents (apart from the standard solution of copper) were added consecutively in a way similar to that used for the plotting of the calibration line. The solution was extracted with chloroform and absorbance of the complex was measured at the organic phase against a reagent blank. The concentration of copper Cx in mg/50 cm3 was read from the calibration line (Benomar and Aguerssif, 2007).

2.9.3 Determination of Manganese (Mn) and Iron (Fe)

The determination of ferrous and total iron with 1, 10-phenanthroline colorimetric reagent, following published instructions, did not correlate with ferrozine method, presenting an erroneous quantification. After neutralizing the extract of 1, 10-phenanthroline with NaOH, both colorimetric methods allowed to quantify with precision and high yield the amount of ferrous and total iron extracted from the soil.

The oxidation states of iron have a different contribution and importance to the environment. In this sense, the improvement of a widely used methodology is crucial for the better study of iron speciation in soil (Gabriele *et al.,* 2021). The content of available iron in soil is accurately determined by electrochemical technique (differential pulse voltammetry) using DTPA-TEA-$CaCl_2$ soil extraction solution directly without acidic digestion treatment (Anderson *et al*., 1992).

2.10 Statistical Analysis

Statistical significance (*P*) is determined by Two-way ANOVA, and values are shown as the mean±SEM. The earthworm growth and reproduction were compared with using analysis of variance (Gomez-Brandon *et al*., 2022).

III. RESULTS

3.1 Result I - Phytochemical Analysis

Phytochemical analysis of *Lagerstroemia speciosa* ethanolic leaf extract shows the major phytocompounds such as Alkaloids, Flavonoids, Saponins, Phenols, Tannins, Protein and Amino Acid, Reducing Sugar, Steroids, Glycosides, Phytosterols, Quinones, and Coumarins.

Table 1 Phytochemical Analysis of Ethanolic Leaf Extract of *Lagerstroemia speciosa*

S. No	Phytoconstituents	Leaf extract
1	Alkaloids	++
2	Flavonoids	++
3	Saponins	+++
4	Phenols	+++
5	Tannins	+++
6	Protein and Amino acids	+++
7	Reducing sugar	+
8	Steroids	++
9	Glycosides	+
10	Phytosterols	++
11	Quinones	+
12	Coumarins	++

(Pavithran and Sujatha, 2022)
'+' indicates the presence of Phytoconstituents
'++' indicates the Phytoconstituents present in a moderate level
'+++' indicates the Phytoconstituents present abundantly

3.2 Result II - Analysis of Compost Media

3.2.1 Determination of Zinc (Zn)
The level of zinc is higher amount in Sample C -49.9±1.015 and very trace amount in Sample D -15.7±0.61.

3.2.2 Determination of Copper (Cu)
The Sample E shows 46.8±0.529 Mn and lowest Sample B -40.3±0.7.

3.2.3 Determination of Manganese (Mn)
The amount of copper in Sample E -21.3±0.92 and lowest in Sample B shows -12.8±0.52.

3.2.4 Determination of Iron (Fe)
The Sample A shows highest amount of Fe -217.9± 0.36 and lowest in Sample C -125.4±0.61.

Table 2 Nutrient Analysis in Compost Media

Variables	Zn (Mg/kg)	Cu (Mg/kg)	Mn (Mg/kg)	Fe (Mg/kg)
Sample A	27.80 ± 0.44	13.1 ± 0.1	46.6 ± 0.44	217.9 ± 0.36
Sample B	33 ± 1	12.8 ± 0.52	40.3 ± 0.7	209.6 ± 0.53
Sample C	49.9 ± 1.015	14.3 ± 0.1	42.3 ± 0.7	125.4 ± 0.61
Sample D	15.7 ± 0.61	18.6 ± 0.4	43.7 ± 1.13	181.6 ± 0.53
Sample E	24.8 ± 0.62	21.3 ± 0.92	46.8 ± 0.529	186.3 ± 0.9
CD ($p<0.05$)	0.9832**	0.685**	0.794**	0.6548**

Values are mean ± SD of three samples in each group. ** - significant at 5% level, ns-Not Significant

3.3 Result III - Weight of the Compost

The initial stage of each sample weight is 7 kg and the final weight of the sample is lower compare to the Initial weight.

3.4 Result IV - Rate of Compost

Aside from secondary nutrient content, temperature profile and presence of cocoon, time is also an important parameter to be considered in vermicomposting process. If it takes more than three months in the process, the qualitative value of vermicompost will deteriorate.

3.5 Result V - Quality of the Compost

The laboratory studies were conducted to investigate the effects of quality parameters, particularly secondary nutrient content, temperature, and cocoon density on vermicomposting process. Earthworm, *E. fetida*, of local variety was used.

IV. DISCUSSION

Micronutrients play important roles in photosynthesis. Micronutrients are important in reactions such as N fixation, Protein synthesis. Micronutrients in plants are beneficial for balanced nutrition of crops. These support all the biological functions of a plant. Their deficiency leads to stunted growth, chlorosis, necrosis, delayed maturity, and senescence. Micronutrients are trace nutrients. Nutrient deficiency symptoms occur as yellowing of leaves, interveinal yellowing of leaves, shortened internodes, or abnormal coloration such as red, purple, or bronze leaves. These symptoms appear on different plant parts as a result of nutrient mobility in the plant. The primary macronutrients are Nitrogen (N), Phosphorus (P), and Potassium (K).

Nitrogen is essential for plant development, since it plays a fundamental role in energy metabolism and protein synthesis. Nitrogen is absorbed by the plant in the form of a nitrate. Deficiency of any of the nutrients affects growth and development. Micronutrients often referred to as vitamins and minerals, are vital to healthy development, disease prevention, and wellbeing. With the exception of vitamin D, micronutrients are not produced in the body and must be derived from the diet. They are relatively required in small amounts when compared to macronutrients.

Both macronutrients and micronutrients are important for a plant's overall growth. Both are equally important and none has an edge over the other. Micronutrients play a central part in metabolism and in the maintenance of tissue function. An adequate intake therefore is necessary, but provision of excess supplements to people who do not need them may be harmful. Single micronutrient deficiency states are comparatively easily recognized and treated. Most micronutrients are part of the enzyme systems of plants.

Zinc is one of eight micronutrients. This micronutrient is essential for plant growth and development. Without adequate zinc, plant vitality suffers and so do produce yields. Zinc can be also applied into soils after fortification of commonly applied NKP fertilizers. One-percent zinc-containing NPK and urea fertilizers are available in many countries. Zinc (Zn) is required for the metabolism of plants, enzyme function, and ion transport. The physicochemical involvement of Zn in soil-plant systems (Prajakta *et al.*, 2022). Consequently, inadequate Zn availability in soil is a main consideration for plant nutrition, resulting in a significant loss in production and grain nutrient content. Brown spots on Upper Leaves Distorted Leaves. Zinc sulfate helps to prevent low yields, spotted leaves and stunted growth. It can also be used as a natural fungicide.

Copper (Cu) is one of eight essential plant micronutrients. Copper is required for many enzymatic activities in plants and for chlorophyll and seed production. Deficiency of copper can lead to increased susceptibility to diseases like ergot, which can cause significant yield loss in small grains. Copper activates some enzymes in plants which are involved in lignin synthesis and it is essential in several enzyme systems. It is also required in the process of photosynthesis, is essential in plant respiration and assists in plant metabolism of carbohydrates and proteins.

Copper (Cu) is an essential micronutrient for humans, animals, and plants, and it participates in various morphological, physiological, and biochemical processes. Cu is a cofactor for a variety of enzymes and it plays an important role in photosynthesis, respiration, the antioxidant system, and signal transduction (Durgesh *et al.*, 2015). Manganese (Mn) is an important micronutrient for plant growth and development and sustains metabolic roles within different plant cell compartments. The metal is an essential cofactor for the oxygen-evolving complex (OEC) of the photosynthetic machinery, catalyzing the water-splitting reaction in photosystem II (PSII). They are boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn). Micronutrients are important for plant growth, as plants require a proper balance of all the essential nutrients for normal growth and optimum yield.

In plants, iron is also required for photosynthesis and chlorophyll synthesis. The availability of iron in soils dictates the distribution of plant species in natural ecosystems and limits yield and nutritional quality of crops. Iron is one of the 17 essential elements (14 mineral elements and 3 non-mineral elements (C, H, O) required for plant growth and development. Although iron is considered a micronutrient and only required in small amounts, it is a critical component for a number of plant processes. Iron deficiency reduces root growth. Iron toxicity (indicated by leaf bronzing) can be serious for production of crops in waterlogged soils. Iron is required for the biosynthesis of the chlorophyll molecule and functions as an electron carrier in the respiration and photosynthesis reactions. In addition, it participates in many enzymatic processes. Iron deficiency is a limiting factor of plant growth. Adding organic compost to the soil in your garden is a sustainable approach to enrich its nutrient content. The micronutrients in grass clippings, leaves, plant trimmings, and table scraps can all be utilised by plants.

V. CONCLUSION

The Present study found that Kitchen waste, soy bean meal maker, Unused Face mask bits, *L. speciosa* dry leaves and cow dung can efficiently be converted into vermicompost employing earthworms. Though, unused face mask bits should be mixed with bulking material in appropriate amount otherwise earthworm growth and fecundity may be adversely affected. Vermicompost's had higher NPK content and secondary nutrients with lesser TOC and C: N ratio than feedstocks.

AUTHORS CONTRIBUTIONS

Author 3* designed the study, wrote the protocol, and wrote the first draft of the manuscript, **Author 1** did the experimental work, performed the statistical analysis, **Author 2** managed the analyses of the study, managed the literature searches. All authors read and approved the final manuscript.

REFERENCES

[1] Thomas, M., Omar, H., Andreas, D. and Philip, J.L. 2023. Soil and water pollution and human health: what should cardiologists worry about? Cardiovasc Res., 119 (2).

[2] De la Rosa, D. 2003. Soil quality evaluation and monitoring. Soil conversation and Protection for Europe.

[3] Javed, A., Garcia, A.L., Leonardo, S., Sarada, K., Fangjun, S. and Krishna, K. 2020. Can face masks offer protection from airborne sneeze and cough droplets in close-up, face-to-face human interactions -A quantitative study. 1; 32(12): 127112.

[4] WHO. 2020. Rational use of personal protective equipment for coronavirus disease 2019 (covid-19). World Health Organization. https://apps.who.int/iris/handle/10665/331215. (Accessed February 27, 2020).

[5] Sarawut, Sangkham., 2020. Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. Case studies in chemical and Environmental Engineering. 2(100052): 1-9.

[6] Ansari, A.A. and Ismail, S.A. 2012. Role of earthworms in Vermitechnology. Journal of Agricultural Technology, 8(2): 405-415.

[7] Vodounnou, D. S, Juste, Vital., Kpogue, Diane, N. S., Mensah, Guy, Apollinaire., and Fiogbe, Emile, Didier., 2016. Culture of earthworm (*Eisenia fetida*), production, nutritive value and utilization of its

meal in diet for *Parachanna obscura* fingerlings reared in captivity. International Journal of Fisheries and Aquatic Studies. 4(5): 01-05.
[8] Bhattacharya, S. S., and Chattopadhyay, G. N., 2006. Effect of vermicomposting on the transformation of some trace elements in fly ash. Nutr Cycl Agroecosyst. 75: 223–231.
[9] Sanandaji, D. S., Fathi, P., Heidari, G., Sharifi, Z., and Khodaverdiloo, H., 2024. Soil properties and quinoa yield as affected by irrigation and vermicompost application under a drip-tape irrigation system. Sec. Agroecology and Ecosystem Services. (8).
[10] Reinecke, A. J., Viljoen, S. A., and Saayman, R. J., 1992. The suitability of *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* (Oligochaeta) for vermicomposting in southern Africa in terms of their temperature requirements. Soil Biol. Biochem. 24(12): 1307-1992.
[11] Dawoud, M. E., and Eweis, M., 2006. Phytochemicals control of edible mushrooms phytogenic bacteria. J. Food, Agri. Environment. 4(1): 321-324.
[12] Abd-El-Khair, H., and Hafez, O. M., 2006. Effect of aqueous extracts of some medicinal plants in controlling the green mould disease and improvement of stored "Washington" Navel Orange Quality. Journal of Applied Sciences Research. 2(10): 664-674.
[13] Johnson, S., Morgan, E. D., and Peiris, C. N., 1996. Development of the major triterpenoids and oil in the fruit and seeds of neem (*Azadirachta indica*). Annals of botany. 78(3): 383-8.
[14] Kongkathip, N. 1994. Chemistry and extraction method of neem- Bankon: 3rd workshop in the neem leaf extracts to control and eradicate insects.
[15] Keerthana, R., Pavithran, S., Ganesan, G., Karthik, M. and Sujatha, P.S. 2023. Growth and reproduction rate of *Eisenia fetida*, using *Lagerstroemia speciosa* and waste disposable face masks to test the NPK level of the compost. Asian Journal of Research in Zoology, 6(4): 44-50.
[16] Broadley, M. R., White, P. J., Hammond, J. P., Zelko, I., and Lux A., 2007. Zinc in plants. New Phytologist. 173 (4): 677–702.
[17] Benamor, M. and Aguerssif, N. 2007. Simultaneous determination of calcium and magnesium by derivative spectrophotometry in pharmaceutical products. Spectrochimica Acta, Part A 69 2008; 676–681.
[18] Gabriele, Veronica, de, Mello, Gabriel., Leonardo, Machado, Pitombo., Luana, Maria, Tavares, Rosa., Acacio, Aparecido, Navarrete., Wander, Gustavo, Botero., Janaina, Braga, do, Carmo., and Luciana, Camargo, de, Oliveira. (2021). The environmental importance of iron speciation in soils: evaluation of classic methodologies. Environ Monit Assess. 193(63): 1-9.
[19] Anderson, G.C., Lefroy, R.D.B. and Blair, G.J. 1992. Soil-extractable sulfur and pasture response to applied sulfur. Australian journal of experimental agriculture, 38(6), 567-574.
[20] Gomez-Brandon, M., Fornasier, F., De Andrade, N., and Domínguez, J. 2022. Influence of earthworms on the microbial properties and extracellular enzyme activities during vermicomposting of raw and distilled grape marc. Journal of Environmental Management, 319, 115654.
[21] Pavithran, S. and Sujatha, P.S. 2022. Phyto-pharmacological activities and GC MS studies on ethanolic leaf, flower and seed extracts of *Lagerstroemia speciosa* (L.) Pers (Lythraceae). European Journal of Biomedical and Pharmaceutical Sciences, 9(11): 282-288.
[22] Pavithran, S. and Sujatha, P.S. 2022. Evaluation of anti-inflammatory properties of ethanolic leaf, flower and seed extracts of *Lagerstroemia speciosa* (L.) Pers (Lythraceae) against carrageenan-induced acute inflammation in albino rats. Journal of Advanced Scientific Research, 13(9): 48-53.
[23] Ganesan, G., and Sujatha, P. S., 2024. Evaluation of phyto - pharmacological properties and GC-MS studies on ethanolic extracts of red and green leaves of *Lagerstroemia speciosa* (L) Pers (Lythraceae). Res. Jr. Agril. Sci. 15(2): 432-436.
[24] Prajakta, Y, Pachorkar., and Vaishnavi, Pawar., 2022. Role of Micronutrients Based Nano Biofertilizers as Biofortifying Agent for Plant Growth Promotion and Development. Res. Jr. of Agril. Sci., 13(4): 1165-1175.
[25] Durgesh, Kumar, Tripathi., Shweta, Singh., Sanjay, Mishra., D, K, Chauhan., and N, K, Dubey., 2015. Micronutrients and their diverse role in agricultural crops: advances and future prospective. Acta Physiol Plant., 37(139): 1-14.