International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

GELATIN – BASED BIOPLASTIC DEGRADATION AND ITS IMPACT ON SOIL FERTILITY

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ABSTRACT :

To explore the feasibility of producing gelatin-based plastic films and subsequent plastic carry bags using gelatin and various other natural things in India. Upon completion, we succeeded in developing a cost-effective alternative compared to other polymeric films by blending gelatin, and glycerol. Tensile testing of the film revealed its efficiency and durability, surpassing films made other materials also. The decrease in puncture and tensile strength with increased glycerol content indicated that excessive plasticizer usage would compromise the film's efficiency. Furthermore, the water absorption test indicated variations in pore size with gelatin, offering valuable data for designing specific food packaging film systems. The results of the water absorption test, tensile strength test, and elongation at break were comparable to existing results. The degradation resistance of bioplastics made from gelatin was notably affected by the amount of glycerol used as a plasticizer, with higher glycerol concentrations leading to faster degradation (complete degradation occurred by the 14th day). Our bioplastic exhibits the look and feel of real plastic while being biodegradable.

Keywords: Bioplastic, Gelatin, Plasticizer, Food Packaging ,polymeric film

Introduction :

The extensive production and use of conventional plastics pose significant threats to fossil fuel resources and the environment. Plastic waste, especially single-use products, contributes substantially to municipal solid waste. Bioplastics, derived from renewable biomass sources such as proteins, polysaccharides, and lipids, offer a sustainable alternative. While starch is abundant and cost-effective, its poor mechanical properties limit its use in bioplastics. Efforts to mitigate plastic waste impact the land, waterways, and air, emphasizing the importance of transitioning to biodegradable alternatives. (Gomez-heincke*et.al.,*2017). The biodegradation research can be carried out in compost, soil, sea water municipal solid waste and digestion process.Soil is extremely complex environment which contains a wide range of properties (e.g. mineral particles and organic matter) and microorganisms, which enables the plastics degradation to be more feasible with respect to other environments such as water or air. Depending on the soil environment, the characteristics of bio-plastics biodegradation can be different. This environment is the least researched among those mentioned earlier. Due to the fact that the process of biodegradation in soil under natural conditions is slow, it allows in-depth investigation of the first stage of biodegradation, which is biodeterioration. Studies on biodegradation in soil are especially important for farmers in order to convince them to use bio-based plastics instead of conventional polyethylene (PE) mulch films (Hayes *et.al.,* 2017).
Although bioplastics currently represent only 1% of total plastic production, there is a growing movement towards their broader adoption. The global biodegradable plastic market is projected to experience significant growth, reaching $6.73 billion by 2025 from $3.02 billion in 2018. This surge is primarily driven by increasing demand for biodegradable polymers in emerging economies like India, Brazil, and China. While starch blends dominate the biodegradable plastics production, polyhydroxyalkanoates (PHA) and polylactic acid (PLA) are key contributors to the growth of biobased biodegradable plastics.(Pimpliskar et al 2023,2020) PHA and PLA collectively hold a market share of 1.2% and 13.9% of the bioplastic market, respectively, by weight of the 2.11 million tonnes of bioplastics produced. Global production of PHA is expected to increase by 6.3-fold from 25,320 tonnes in 2019 to 159,700 tonnes by 2024, while PLA production is projected to rise by 8% from 293,290 tonnes in 2019 to 317,000 tonnes in 2024.
Gelatine, derived from collagen, is proposed as a potential substitute due to its biodegradability and biocompatibility. The present work represents the small effort towards sustainable development through gelatine based bio plastic potential.

2.Material and Methods :

2.1 Materials:

Gelatin powder , Glycerin Distilled water Food colour

2.2.1Method:

- Prepare Work Area: Gather all the necessary equipment and ingredients. Ensure you have a hot plate, pot, beakers, scale, stirring tool, spoon, gelatin powder, water, glycerol, and mold ready. Having everything organized and within reach will streamline the process.
- Pour Cold Water into Pot: Measure out 240ml of cold water and pour it into the pot. This serves as the base for the gelatin mixture.
- Measure Gelatin Powder: Using a food scale, measure out 48g of gelatin powder. Add the measured gelatin powder to the cold water in the pot. Gelatin acts as the primary binding agent in this bioplastic recipe.
- Measure Glycerol: Determine the desired flexibility and texture of the bioplastic by measuring out 12g to 24g of glycerol. The amount can be adjusted within this range based on preferences. Add the measured glycerol to the mixture in the pot. Glycerol helps control the flexibility of the final product.
- Stir Ingredients: Stir the mixture in the pot thoroughly until there are no clumps present. This ensures that the gelatin and glycerol are evenly distributed throughout the solution.
- Heat Mixture: Place the pot on the hot plate and heat the mixture until it starts to froth at a low boil. Continuously stir the mixture while heating for a few more minutes to ensure even heating and prevent clumping.Remove Excess Froth: Use a spoon to skim off any excess froth that forms on the surface of the mixture. Ensure there are no clumps remaining in the mixture. The excess froth can be saved separately if desired for texture or discarded.
- Remove from Heat: Once the mixture has been heated and stirred adequately, remove the pot from the heat source to prevent overcooking or burning.
- Add Dye (Optional): If desired, add pigment to the mixture for coloring. This step can be done either before pouring the mixture into the mold or after. Adding pigment to the hot solution may result in more even color distribution but could slightly fade the color.
- Pour Mixture into Mold: Carefully pour the liquid mixture into the mold or onto a surface, spreading it evenly to form a thin layer. The thickness of the layer will influence the drying time.
- Wait and Dry: Allow the bioplastic to dry for 2-3 days. The drying time depends on factors such as the thickness of the bioplastic, temperature, and humidity. Bioplastics typically dry faster in warmer conditions and slower in cooler conditions. After 24 hours, cut the edges of the bioplastic from the mold using an exac to blade or knife. Once dry, carefully remove the sheet from the mold.

2.2.2 Degradability analysis:

The investigation into the biodegradability of PPB and CB samples was conducted in various controlled environments (Maran, J. P., et al., 2014). Two different PPB and CB samples were buried under 50 g of moist soil and 50 g of vermicompost (Ashok A., R. Abhijith, et al, 2018) in petri dishes, respectively, after weighing. Bioplastic samples, with known initial masses, were weighed weekly after burial. All experiments were replicated three times. According to the European Committee for Standardization (CEN), biodegradation refers to degradation caused by biological activity, particularly enzymatic action, resulting in a significant alteration in the chemical structure of a material. Additionally, weight loss measurement is a standardized method for assessing polymer biodegradation (Mahalakshmi V., 2014). The degree of biodegradation was determined using the following equation (Ismail, et.al., 2019).

$(W0 - W) / W0 \times 100$

where W0 and W represent the initial and final weights of the bioplastic samples, respectively. WL denotes the weight loss.

2.2.3 CALCIUM CARBONATE TEST:

20gram of soil is measured by using weighing balance. Then it is taken in beaker and 15ml of dilute hydrochloric acid is added into it. If vapour is observed then it shows presence of calcium carbonate in the soil sample.

The enhancement of mechanical properties in soils with poor geotechnical characteristics for construction often necessitates intervention. One promising technique involves microbiallyinduced calcium carbonate precipitation ($CaCO_3$), also known as biocalcification

2.2.4 HUMIDITY TESTING:

20 gram of soil sample is measured using weighing balance and it is taken in petriplate. Then these sample is kept in hot air oven for 24hours. Moisture content present in the soil is evaporated in hot air oven at $100^{o}C$.

2.2.5 PH TESTING:

Soil pH, indicative of active hydrogen ion (H^+) concentration in the soil solution, plays a critical role in assessing soil salinity, acidity, or neutrality. It significantly influences nutrient availability to crops and microbial populations within soils.PU was tested with PH meter and paper strips.

2.2.6.OXYGEN TEST:

10grams of soil sample is added into the beaker containing 10ml of water. If there is any bubbles are observed then shows the presence of oxygen in the soil sample.

The oxygen content of soil is vital for aerobic microorganisms, which use oxygen as a terminal electron acceptor during degradation of organic compounds. The presence of oxygen in soil is necessary for such decomposition.

2.2.7 Water holding capacity test:

20gram of soil sample is weighed by using weighing balance. Then 20ml of water is added using measuring cylinder in beaker. Then it is mixed by using glass rod. Then this mixture is filtered by using filter paper. At the end result is observed by comparative study of volume of water.

3.Result and Discussion

Bioplastic formation

Having prepared the bioplastic by above method, it was observed that upon sun drying for 24h, bioplastic was found to be partly dried. On further sun drying for 4 days, it was found to be completely dried. This was followed by Solubility test.

Comparison of the dryness of plastic with respect to period of drying	
Time	Partly sun dried
24 hours	Not completely dried
48 hours	Not completely dried
72 hours	Almost dried
96 hours	Completely sun dried

In the current project, bioplastic was prepared using an Indigenous method. It was observed that after 24 hours of sun drying, it was partly dried, and after 48 hours, it was completely dried.

3.2. Water holding capacity

Water holding capacity before degradation of bioplastic	Water holding capacity after degradation of bioplastic
Sample 1.: Cricket ground 17 ml absorbed by soil from 50 ml water	Sample 1.: Cricket ground 16ml absorbed by soil from 50ml water
Sample 2.: Dumping yard 16 ml absorbed by soil from 50 ml water	Sample 2.: Dumping yard 14 ml absorbed by soil from 50 ml water

3.5 Calcium carbonate test

Before degradation of bioplastic in soil:	**After degradation of bioplastic in soil:**
Sample 1: Farming area- $CaCO_3$ is absent Sample 2: College area - $CaCO_3$ is absent	Sample 1: Farming area- $CaCO_3$ is absent Sample 2: College area- $CaCO_3$ is absent

3.6. Humidity test :

Moisture content before degradation of bioplastic	**Moisture content before degradation of bioplastic**
Cricket ground: 7.925 g reduced from 10 g	Cricket ground: 6.431 g reduced from 10g
Dumping yard: 9.201 g reduced from 10g	Dumping yard: 6.832 g reduced from 10g

3.7 Oxygen test

Before degradation of bioplastic in soil:

Sample 1: College ground – Oxygen is present Sample 2: Dumping yard- Oxygen is present

3.8 PH test : Soil pH, or soil reaction, measures the acidity or alkalinity of soil on a scale of 0 to 14, with 7 as neutral.

PH test before degradation of bioplastic in soil	Ph test after degradation of bioplastic in soil
Cricket ground: 5	*Cricket ground: 6*
Dumping ground: 8	*Dumping ground: 9*

After degradation of bioplastic in soil change in parameters of soil was observed. In farming area sample water holding capacity of soil is decreased from 14ml to 11ml and in college area sample it is decreased from 15ml to 12ml. Before and after degradation of bioplastic in soil no change was observed in calcium carbonate test in both soil samples. After degradation of bioplastic in soil causes decrease in moisture content in both soil samples. In farming area P^H became less acidic and in college sample P^H became more basic. Before and after degradation of bioplastic in both the samples oxygen was present.

Conclusion :

Gelatin is an edible active material that can be used to prepare edible films and coatings. It is an effective material for preserving fresh food due to unique antibacterial and antioxidant properties. However, gelatin, with high water solubility and high viscosity, is greatly affected by natural weather conditions and air humidity, thus there are still great limitations in food packaging.

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