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# Experimental study of bioplastic degradation in soil and water

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**Abstract: -** The bioplastic synthesized using starch, cellulose and glycerol and graphene oxide. The research paper renders the bioplastic response to soil and water by studying their fundamental properties such as weight and pH value respectively. It has been surveyed that plastic products after their use are making enormous quantity and quality of pollution in the surrounding. Thereby creating havoc on blue planet [1]. The synthesis of bioplastics has been done in the laboratory with a view to getting efficient bioplastics. The ratio of ingredients has been altered several times to achieve proper compatibility. The sample of bioplastic has been kept in the water for 25 days (about 3 and a half weeks) and in the soil for 4 months. The pH meter and electronic weight balance in used for the reading purpose. The objective is to achieve sustainability by synthesizing harmless products and ecofriendly products which should not be a contributor to any type of pollution such as soil and water [2].

**Keywords: -** Environment, pH, bioplastic, Sustainable, soil, water.

**Introduction:** -There are plastic materials that show biodegradability because of their ingredients, composition and structure. There are plastic materials that show non biodegradability due to their ingredients, composition and structure [3]. The ingredients, composition and structure decide the degradability of plastic materials. The biopolymers obtained from organic matter are susceptible to biodegradation in the environment spontaneously because of microorganism present in the environment and those ultimately assimilate into soil and retain their original form at the end [4]During the process of biodegradation generally it emits carbon dioxide and water vapors without any toxic, harmful substance and it is generally referred as an aerobic biodegradation. Generally, there are two types of plastics available in the commercial market hydro-biodegradable and oxo-biodegradable bioplastic. Bioplastic does not take thousands of years to degrade like fossils-based plastics. Biodegradation can be done by microbes such as

bacteria, fungi and algae. The only sustainable solution easily available is biodegradation and thereby it may control plastic waste to a larger extent. Starch based bioplastics are hydrophilic that means water, moisture sensitive and more susceptible for biodegradation. Polyolefin's and polyesters are best recommended for eco-friendly packaging. There are a few limitations that have been revealed during the studies of biodegradation. Mainly biodegradation is the natural bioplastic possesses high glass transition temperature. Due to intermolecular interactions among the chains, there is formation of stiffness thereby it results in brittleness in bioplastic character. Therefore, there are compatibility issues during the recycling process [5]. During recycling bioplastic may inculcate unwanted particles during the recycling process and thereby product may form with defects. The degradation speed of bioplastic in soil is closely related to the key ingredients in bioplastic. There are varieties of plastic materials used commercially in large scale out of these materials most are recyclable, compostable and biodegradable. There is fossil based non degradable plastic generating pollution and havoc on blue planet. PET, HDPE, LDPE these plastic materials can be recycled again and again, and reused others can be added in virgin plastic materials. Furthermore, when experimenting on polystyrene (PS) after recycling, PS is used as reinforcing / filler material for other products. Types of natural, artificial and biosynthetic polymers are biodegradable and naturally degradable. A polymer comprises on C-C backbone are not susceptible and resist degradation, whereas A polymer comprises heteroatom's in the backbone found to be vulnerable for degradation. Therefore, degradation of polymer can be increased by making it more judicious in its linkage and contains. The microorganism can eat and digest plastic polymer and starts chemical, mechanical or enzymatic ageing [6].

**Review Literature: -** Fundamental properties of the bioplastic sample need to be tested to get an idea about status. Properties such as water solubility, glass transition state, external observation i.e. physical changes such color, texture, strength by touching the sample. Most of the organic polymers when exposed to sunlight, the energy of sunlight causes breakdown of polymeric C-C bond it is a consequence of deterioration [7]. Further it leads to degradation the process is called as photo-oxidative degradation. When such a process occurs, there is break down of double and triple C-C bond. During the process there is formation of succinic acid ($C_4H_6O_4$) which is dicarboxylic acid and acts as a biological agent play many roles. It is a non-toxic and does not leave Microplastics fragments in the environment. The temperature in the landfills generally reaches 80 to 100 °C which is sufficient and additionally humidity, moisture present over there, therefore it is found to be vulnerable and susceptible for degrading plastic such as polylactic acid. The artificial composter has been established by reputed industries such as Coca-Cola, Coca-Cola is known for taking the initiative to use PLA and composting it there itself. From 1950 plastic production has been increasing. There are generally seven types of well-known plastic (crude oil based) after use plastic life is 20 years to 500 year is considered of bioplastics and their properties relevant to degradability

| Types of bioplastics and their properties relevant to degradability | | | | |
|---|---|---|---|---|
| **Type of polymer** | **Type of structure** | **Mw Kg/m3** | **Degradation rate** | **Application** |
| Starch based plastic | Semi-Amorphous | 30-130 | 100% in 100 days | Food packaging, medical devices |
| Polylactic acid | Amorphous | 100-300 | 50% in 18 months | Medical devices, food packaging |
| Polylactic acid E-Caprolactam | Amorphous | 100-500 | 100 in 4 months | Catalyst, RIM |
| Polyglycolide | Amorphous | 40-100 | 100% in 60 days | Bone, tendon, cartilage, tooth, spinal regeneration |

**Table 1.1** Types of bioplastics and their properties relevant to degradability

**Mechanism:** - Biodegradation process includes the following three steps.

1. **Biodeterioration: -** In this process chemicals in the atmosphere play an important role. When material is exposed to an open atmosphere, the abiotic factors such as temperature, sunlight work on surface of the material thereby decreasing its mechanical strength, changes its chemical structure and physical properties. All the above takes place in the initial stage. The term used bio-deterioration for undesirable action of Microorganism of manmade materials such as corrosion on metal, worsening of concrete and stone of the structural monuments by the growth of microorganism.

2**. Bio Fragmentation: -** It is the process of destroying an infected cell or part of plastic material. It converts polymer into its monomer or oligomer by breaking its bond. It is the lytic cycle. There are two types of bio fragmentation processes aerobic and anaerobic. The aerobic process takes place in the presence of oxygen; the final by-products are CO2, H2O, and other residues. In anaerobic process, it takes place without oxygen and the final by-products are CO2, H2O, and CH4. In industry anaerobic process is preferred because it is rapid, convenient and reduces the mass volume ratio of the decomposer.

3. **Bio-assimilation:** -It is a process in which product from bio fragmentation is further undergo biotransformation to yield the final product that can be transported inside the cell. In the cell it adopts the catabolic pathway that leads to the production of ATP (Adenosine triphosphate) or element of the cell structure the reaction of Aerobic biodegradation

C-Biomass + CO2 + H2O◊C-Polymer + oxygen

The reaction of anaerobic biodegradation

C-Biomass + CO2 + H2O + CH4◊C-Polymer + C- residue

**Factors mainly affecting the biodegradation are as follows: -**

1. Light (sun light or light in composter)
2. Oxygen level (in environment or in the composter)
3. Temperature (in environment or in the composter)
4. Humidity (in environment or in the composter)

5. PH value (in environment or in the composter)

6. Presence of chemicals (in environment or in the composter)

7. Types of enzymes, Extracellular or Intracellular

8. Degree of crystallinity in the polymer

9. Ingredients in polymer/plastic materials or type of plastic material.

10. Technology of biodegradation.

Ø **Biological method of degradation:** -In this method microorganism plays an important role, microorganism secretes a variety of enzymes. These enzymes are responsible for biodegradation.

1. **Bacteria:** The bacteria such as Pseudomonas and streptomycin found in marine and degraded plastic material such as polyethylene, polyurethane (PU), PCL, PVC.

The bacteria Coma monas is usually found in soil and water and biodegrades PU. The bacteria bacillus is ubiquitous, meaning it is everywhere that degrades PU, PE, PVC, PLA, PCL.

The Staphylococcus present in the soil and water efficiently denatures it or breaks the structure of Bioplastic.

2**. Algae:** -The Anabaena usually lives in freshwater and marine water and polyethylene is its prey. The Navicula is a kind of algae that occurs in depth of water bodies, and it digests, degrades LDPE. The chlorella is single celled green alga that works on Bisphenol-A and Polyethylene.

3. **Fungi:** -The Aspergillums is a multicellular fungus, it is a crucial tool in biotechnology, it is ubiquitous and found everywhere it degrades PE, PCL, PBS and PVC. The penicillium usually lives in salty water, salty soil or in food products that degrade or denature PHB, LDPE. The Mucor has nearly 3000 members. They live together in colonies and grow faster, initially they look white and look brown as they age, and specifically it digests LDPE

The degradation speed of bioplastic is also dependent on the number and proportion of bacteria present in the soil. Generally, the degradation causing bacteria decides the quality of soil; it is also known as fertile soil. The present bacterium in the soil efficiently degrades the bioplastic and converts it into fertility aid biomass in the soil. The degradation of bioplastic in soil does not affect the diversity of bacteria. Only starch-based bioplastic has the ability to maintain the quality of soil, other plastic may harm the soil fertility. In The future usage of bioplastic in agriculture sector may increase therefore efficient method for degradation of plastics needs to develop. Starch degrades in the soil and in water; it is biotic type of degradation. It takes place in the network type of reaction rather than linear pathway. It is extensively studied in Arabidopsis leaves and cereal endosperm. In the water gelatinization of starch takes place. In nature cellulose degrades in the soil or water by various microorganisms. Degradation is carried out by enzymes known as cellulose which are secreted by cellulolytic bacteria and fungi. The glycerol rapidly biodegrades in the soil up to 98.7 % within 24 hours it based on Chemical oxygen demand COD value. It is harmless to the environment. The rate of degradation is 85.0 mg COD/g/h. In other places it produces acetaldehyde and acrolein. Acid vinegar is biodegradable in soil and water. It is harmless to the environment.

**Methodology used to synthesis Bioplastic: -**

First take clean water on hot plate for 5 minutes at temperature 60oC then add starch stir the mixture well then gradually add glycerol half % then add cellulose again further add remaining glycerol then add acid vinegar stir it and at last add graphene oxide. Stir it properly mixture shows off white color temperature raise to 70 oC then spread the material on aluminum foil for 24 hours and then remove it.

**Formulations and ratio have been given are as follows**

Water+ Starch + glycerol + cellulose fiber + acid vinegar + graphene oxide,

First specimen: - 60 ml + 10 ml + 5 gm + 2 gm + 2 ml + 0.5 gm

Second specimen: - 60 ml + 15 ml + 5 gm + 2 gm + 2 ml + 0.5 gm

Third specimen: - 60 ml + 20 ml + 5 gm + 2 gm + 2 ml + 0.5 gm

**Testing characterization: -** Given procedure has been implemented for 3 specimens and for both test water and soil.

1. Determination of weight of sample done by using electronic weight balance.
2. Determination of pH of $H_2O$ has been done by using digital pH meter for both steps before and after.
3. Determination of $H_2O$ absorption test has been done by following steps

•Specimens are clean and dried in oven for 10 minutes at a temperature of 25°C. Then placed in desiccators to cool down and immediately weighed.

•A specimen immersed in water for 24 Hours at room temperature then dries in open atmosphere for 5 minutes and weighed.

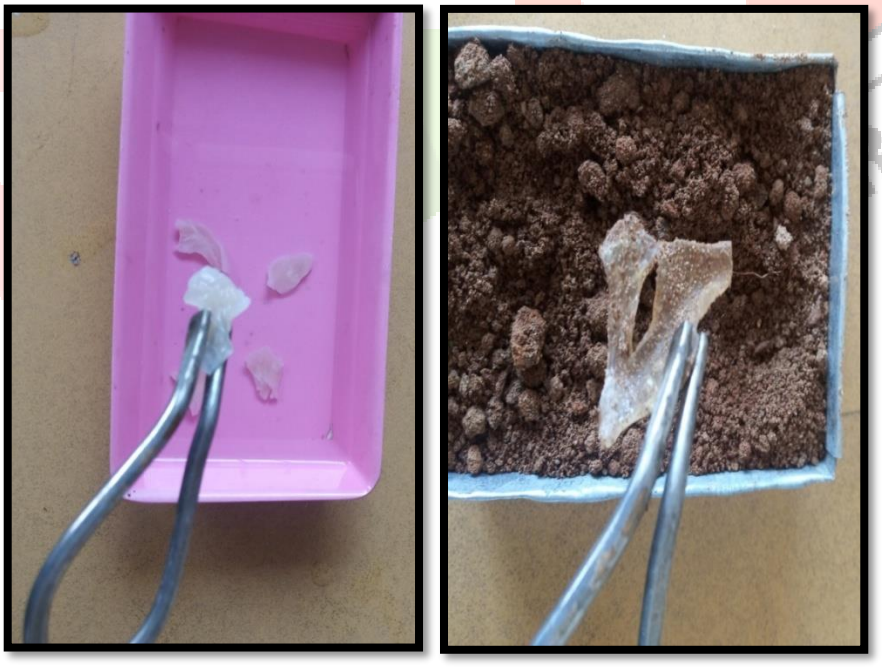


**Figure 1.1** Bioplastic sample in water and soil.

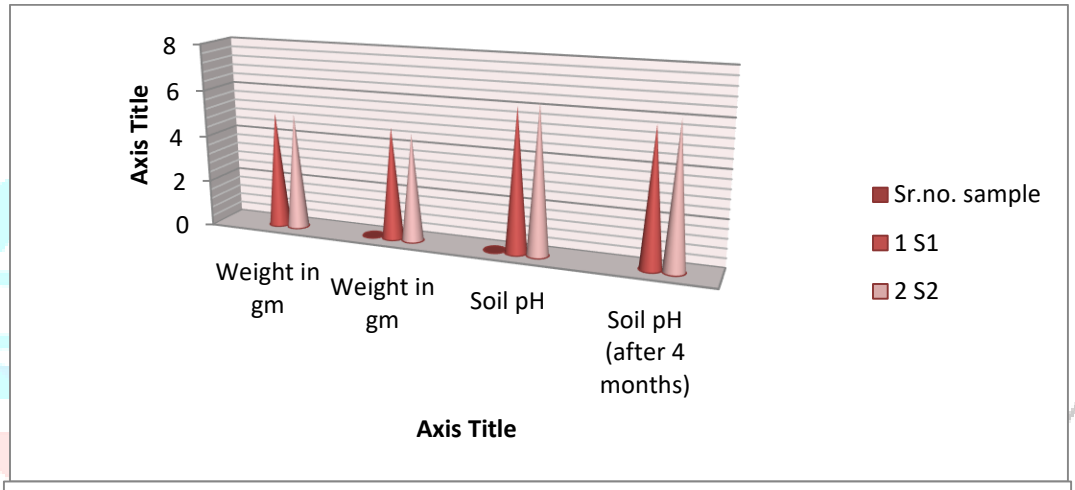
Types of natural, artificial and biosynthetic polymers are biodegradable and naturally degradable. A polymer comprises on C-C backbone are not susceptible and resist degradation, whereas A polymer comprises heteroatom's in the backbone found to be vulnerable for degradation. Therefore, degradation of polymer can be increased by making it more judicious in its linkage and contains.

The microorganism can eat and digest plastic polymer and starts chemical, mechanical or enzymatic ageing

**Results: - Water**

It has been found that in the results, the proportion of starch is more water absorption capacity of bioplastics is more. The pH of water decreases due to starch because starch is a weak acid in comparison to water. Therefore, it has been pH of the water decreases means acidity increases.

| Sr.no. | sample | Weight in gm before Absorption test | Weight in gm after Absorption test | H2O, pH | H2O, pH After24 hrs. |
|---|---|---|---|---|---|
| 1. | S1 | 5 | 5.3 | 7.1 | 7.0 |
| 2. | S2 | 5 | 5.6 | 7.2 | 7.1 |
| 3. | S3 | 5 | 5.8 | 7.1 | 6.8 |



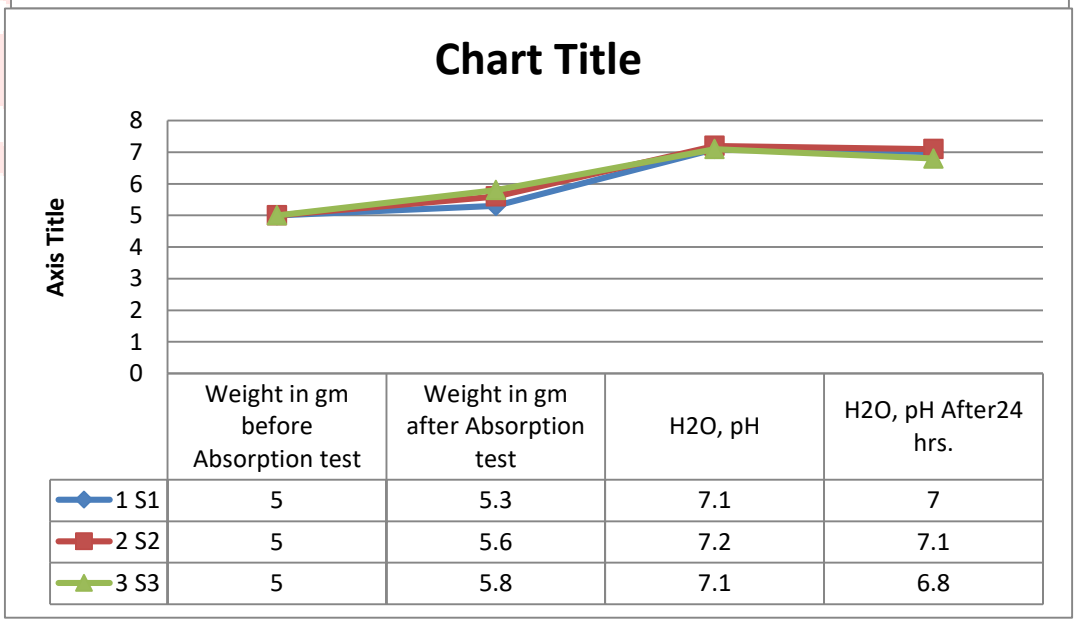



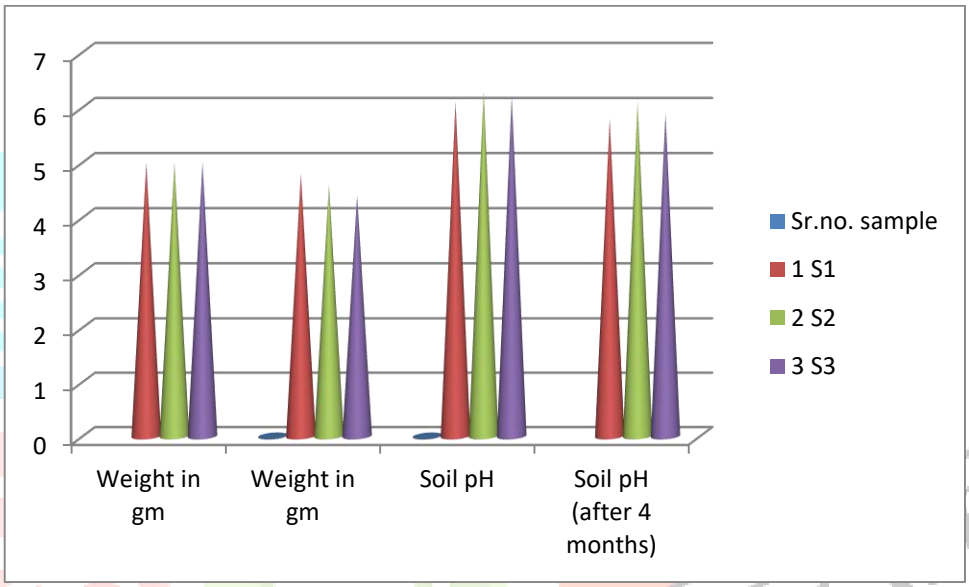

**Table1.2** Bioplastic test in the water

**Results: - Soil**

It has been found that in the results, the proportion of starch is more the disintegrations of bioplastics are more in the soil. The pH of soil decreases due to starch because starch is a weak acid.

| Sr.no. | sample | Weight in gm | Weight in gm (after 4 months) | Soil pH (In the initial) | Soil pH (after 4 months) |
|---|---|---|---|---|---|
| 1. | S1 | 5 | 4.8 | 6.1 | 5.8 |
| 2. | S2 | 5 | 4.6 | 6.3 | 6.1 |
| 3. | S3 | 5 | 4.4 | 6.2 | 5.9 |

**Table1.3** bioplastics Test in the soil



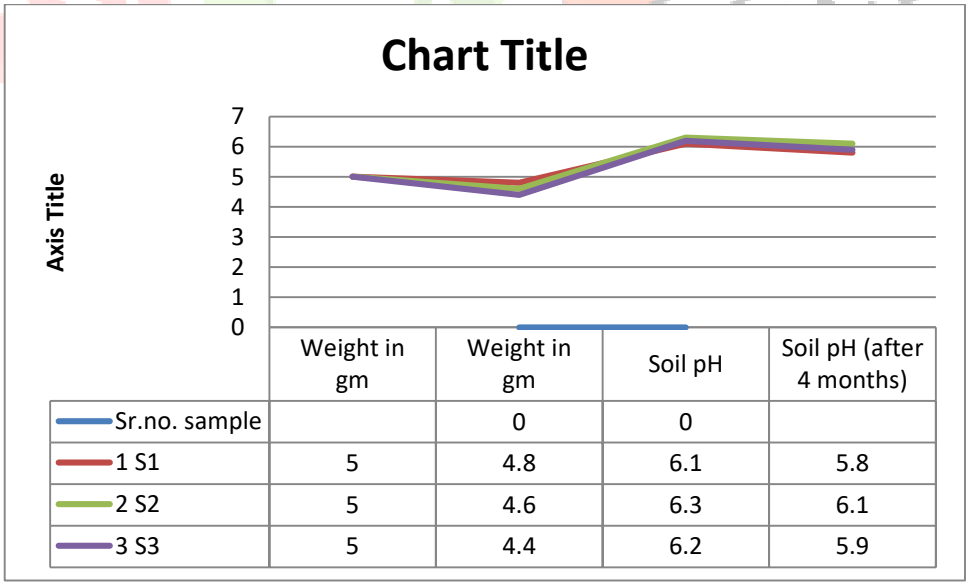




**Table1.2** Bioplastic test in the soil

**Conclusion: -** There is an enormous opportunity in the research of bioplastics. This paper renders only two limited tests as given in the results that show proportion of starch plays a vital role in the degradation of bioplastic in the water and soil. The outcome is that bioplastics mingle with earth, it not harmful as conventional crude oil base plastic, bioplastic is a harmless product.

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