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Biodegradable Bioplastic Produced By Microorganism

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ABSTRACT:- Plastics offer a variety of advantages or benefits, due to its flexibility it has wide applications in modern world. However, use of too much plastic can put effect on the environment and human life.

Need for the production of biodegradable plastic (plastic that can be decomposed in the environment by the action of naturally occurring microbes) has been increasing day by day. There is an extensive need to produce biodegradable plastic due to its ability to decompose itself in short period of time hence saving environment.

This production can be achieved using agricultural waste/s as raw material including banana/fruit peels, cassava starch, corn, wheat straw, rice straw etc. Starch and cellulose are the major raw material for the production of biodegradable plastic. Cassava is one the richest source of Starch.

Cassava is non-toxic, biocompatible, low cost and renewable carbon rich organic raw material. Other several source of plastic production can be there. In today's world, 66% of the global biodegradable plastic production can be shifted to the bioprocesses based on the starch as raw material. Potato starch is another example of Starch product which is act as a raw Material to produced biodegradable plastic.

Another starch product which include in this bioproduction is corn. It has properties like easy availability, richness in nutrients and presence of simple nutrients, which make it a material of choice for bioplastic production.

I. INTRODUCTION:-

The plastics have become an important part of each and every aspect of modern life. It offers a variety of benefits due to its flexible size, light weight and cheaper cost, which make it a material of choice in nearly all the applications of household and industries. But the excessive and unwise use of plastic results in deterioration of environment and has harmful effect on human health.

In order to solve this problem, there is need to produce an alternative way such as production of Biodegradable Plastic Biodegradable plastic can be defined as plastic that can decompose in the environment by the action of microorganisms such asbacteria, fungi and algae.

The advantage of using biodegradable plastic is its ability toundergo decomposition in short period of time without any harmful effect on the environment. It is eco-friendly plastic and made from potentially inexpensive raw material. Moreover, the manufacturing cost of biodegradable plastic is less as compared to conventional plastic

Agricultural waste contains various raw materials which can be used in production of bioplastics e.g. potato peel, tomato, cornhusk, wheat straw, rice straw and banana peel. Cheese whey is another major raw material. It is estimated that about 998 million tons of agricultural waste is produced yearly. So, management of agricultural waste is considered to great strategy for controlling environmental pollution

Properties of Bioplastics:-

The biopolymers' capacity to make their way to the market is mainly due to their propertiesthat are not at all inferior to those of the conventional petrochemical polymers.

Bioplasticsare mostly known for their environmentally friendly nature due to their lower persistence whenabandoned in the environment. Through the utilization of renewable resources such as organic waste , there exist additional benefits by the valorization of solid waste that would beotherwise landfilled or used for energy recovery Another property of the bioplastics is that theyare non-toxic and compostable, which means that they are not harmful to living organisms .

A crucial point is that biopolymers should have similar mechanical chemical, andphysical properties to conventional plastics These include tensile strength, tensile elongation,elasticity, flexural strength, density, crystallinity, melting point, water vapor and oxygen permeability,

and also UV resistance

However, the often low mechanical strength of bioplastics is the property that mostly limits theirapplication and requires the use of synthetic fibers, such as glass or carbon, to increase this property . This leads to environmental problems due to reduction of their biodegradability As a replacement of synthetic fibers, environmentally friendly materials, such as lignocellulosic fibers, fillers derived from cellulosic materials starch can be added to biopolymers to reinforce the produced bioplasticNanomaterials, such as nanoclay or chitosan have been usedto increase the thermal stability of bioplastics developed from starch which are known to have poor mechanical properties, due to their intra- and intermolecular bonds [Moreover, in a studyconducted by Masruri and co-workers the addition of essential oil from kaffir lime to starch fromcassava peel waste to produce bioplastic was found to increase the stability in tensile strength and theplastic was able to elongate by 65–85%. The simple addition of glycerol at a concentration of 5% (w/w)produced a bioplastic with a higher tensile strength of 205.52 N mm−2 and 42.69% of elongation

The addition of PLA (10%) to starch-based bioplastics enhances the general properties of bioplasticcomposites PHAs have mechanical properties similar to synthetic plastics, are insoluble in water,and non-toxic, which makes them suitable for biomedical applications

Advantages:-

- **Biodegradable Plastics are Easy to Recycle:-**

These types of plastics not only take less time to decompose when discarded but can also be easily recycled through an organic process. They are also non-toxic since they have no chemicals or toxins. Recycling helps to lessen landfill problems, and besides, the recycled bio-waste can be used as compost or as renewable energy for biogas.

- **ADVERTISING:-**

READ US Cities You Should Consider Moving To if You Are Eco-ConsciousThey Consume Less Energy During Their Manufacture It is true that the production of biodegradable plastics requires more investment, but finally, it is worth it. If the clean-up costs are taken into consideration, besides the harmful effects on the environment, biodegradable plastic products will definitely turn out to be a wiser choice.

Less energy is needed in the manufacturing of biodegradable plastics compared to ordinary plastics. For instance, the manufacture of corn-based polymer requires 65% less energy compared to a similar polymer made from petroleum. Manufacturing bioplastics also do not require the process of finding, accessing, and transportation of hydrocarbons.

This means fewer fuel fossils will be in use; hence, reduction of environmental pollution. Also, it produces 68% fewer greenhouse gases during its manufacture, posing a significant environmental benefit.

- **Reduction of the Amount of Waste Produced**

Biodegradable plastic breaks down only in a period of a few months, depending on the material used to make the bioplastic and the method of disposal. Other types of traditional plastic constitute 13 percent of the stream that is 32 million tons of trash annually, and only 9 percent of this type plastic can be recycled.

Biodegradable plastics are a better choice as they are broken down easily, and can be absorbed by the soil or converted into compost. Moreover, even if a complete breakdown does not occur, it is easy to achieve a reduction in the amount of space required to dispose of the globe's plastic waste.

- **Lower Petroleum Consumption**

Oil is a significant ingredient in the manufacturing of traditional plastics. Petroleum is known to have negative impacts on the environment, the amount of waste produced during refinement and also during the extraction of oil from the earth.

It is surprising to note that, in the United States alone, 3% of petroleum so produced is used in the manufacturing of plastics. What we must remember is that, like other fossil fuels, petroleum is a non-renewable resource that ought to be conserved.

Biodegradable plastics usethe idea of natural products; therefore, the use of bioplastic can profoundly reduce the amount of petroleum used and consequently lessen its environmental hazards.

- **Compostability**

Composting of bioplastic products can make the soil fertile, thereby enhancing soil fertility. The reason for this is because plastic is not made using artificial chemicals but from natural materials. The materials decay and improve the soil's water and nutrient retention and help in the growth of healthier plants with no need for pesticides and chemical fertilizers.

- Reduction of Carbon dioxide Levels

We are at a juncture where we are producing the largest amount of waste that the history of human civilization has ever seen. And needless to say, it is plastic products that form a major chunk of it. The situation is such that even our drinking water sources, which constitute a mere 1% of earth's total water resources, are getting contaminated at an alarming rate.

Disadvantages of Biodegradable Plastics:-

- Engineering Problems Biodegradable plastics are made from plants such as soybeans and corn. Therefore, there is a risk of contamination as the crops are typically sprayed with pesticides when on the farm and can easily be transferred or included in the end product.
- Need For Costly Equipment For Both Processing and Recycling A downside of biodegradable plastic is that there is a need for costly industrial processors and composters, especially those that require high I n dustrial-scale temperatures to be broken down. Apart from cost, there is a for the availability of equipment, which may be a problem.
- Risk of Contamination Due to Confusion Differentiating Between Bio-degradable and Non-Biodegradable PlasticsThese bioplastics should not be mixed with non-biodegradable plastic when discarded. The challenge today is that many people do not know how to distinguish between the two.
- READ 30+ Surprising and Innovative Ways For You To Save Rainforests Therefore, these bioplastics may end up getting contaminated and may not be easily recyclable anymore. The outcome is adding up to the waste volume.
- Biodegradable Plastics May Produce Methane in Landfills Some biodegradable plastics produce methane when decomposing in landfills. The amount of methane produced each year is high. Methane is 84 times more potent than carbon dioxide, and it absorbs heat faster; therefore, it can accelerate climate change.
- Surprisingly, Biodegradable Plastics do not Solve Ocean Pollution ProblemsThese types of plastics cannot decompose in the ocean waters as it is too cold. Therefore, these plastics will either float on water or create micro-plastics which pose health hazards to marine life. Thus, the use of these kinds of plastic cannot solve all pollution problems.
- There is a Need For More Crops and Croplands to Produce Biodegradable PlasticsAdequate production of these kinds of plastic will require the use of cropland to provide the natural materials required instead of producing food. With food scarcity and hunger affecting 1 out of 5 families in the developed nations and much more in developing countries, there is an ethical question whether it is right to expand this industry.
- Biodegradable Products Come at a Higher CostIt costs 20 – 50% more to produce bioplastic than to produce traditional plastic. With improved technologies and more access to materials, however, this cost can reduce significantly.
- Biodegradable Plastics May Contain MetalsSome of these plastic products, for example, plastic bags, may release some amount of heavy metals during decomposition. For example, the Guardian reported high levels of cobalt and lead in one brand of this kind of plastic. It raised issues about the toxicity left after decomposition.

Objective:-

- Microbial degradation: The primary purpose of biodegradable plastics is to replace traditional plastics that persist in landfills and harm the environment. Therefore, the ability of microorganisms to break down these plastics is an incredible environmental advantage.

- Elimination of waste management: Our biodegradable plastics will break down naturally on land (with OK biodegradable SOIL certification) so removal and transportation of the waste will no longer be needed. Costs of management for farmers/growers and the environmental problems associated with landfills and incineration will be erradicated.

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- Development of new biodegradable plastics films with a very low carbon footprint impact: Conventional agricultural plastic films have an enormous environmental impact in terms of CO_2 emissions during their life-cycle. We will significantly reduce this impact, since our biodegradable polymers and additives will be made from renewable raw materials that are not petro-based and do not compete in food markets. Also, biomass for these biodegradable plastics will come from trees and crops which extract CO2 from the atmosphere as they grow.
- Improvement of soil and product quality: Conventional agricultural films present toxic components and contaminate the soil in a number of ways. Multibiosolbioplastics will not only avoid these harmful components, they also will add value through Oligo Elements (trace minerals as natural fertilizers) and micro-perforation functionalities that contribute to agriculture à la carte and help improve the health of the soil and the quality of the final product.

Production Of Biodegradable Plastic From Cheese Whey:-

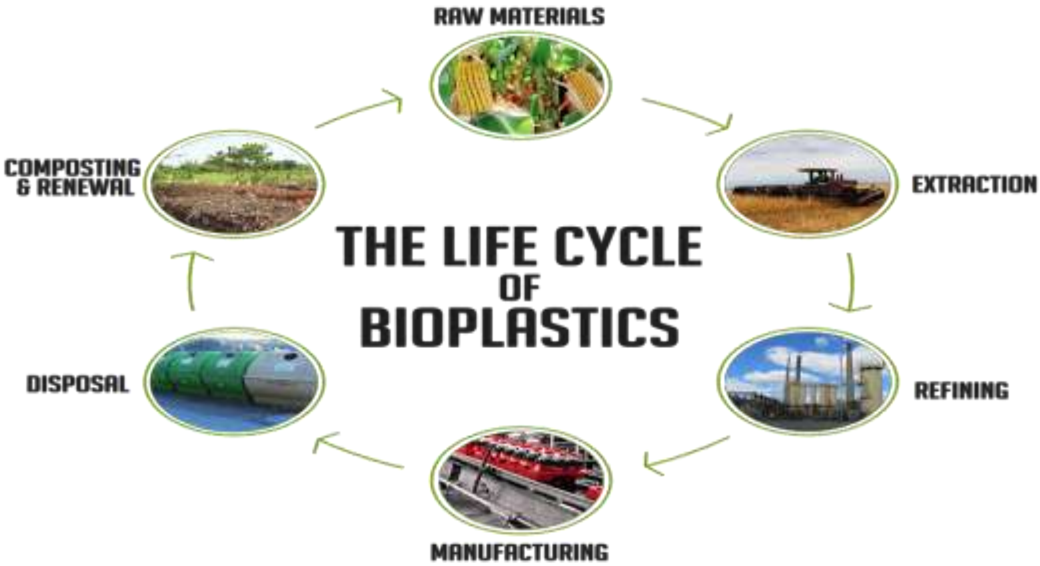
Whey is the byproduct of cheese production. It has high importance in the dairy industry. It is the liquid Released during cheese making after coagulation and separating casein from milk.

It has various properties such as high nutritional composition and high BOD (Biological Oxygen demand) and COD (Chemical Oxygen demand). Whey production is estimated at around 180 - 190 x 106ton per annum.

According to survey only 50% of worldwide cheese whey product can be transformed into various other food products
It can be used for production of various other products like animal feed, can consumed as whey protein and use as an additive in various processed food through bacterial and yeast fermentation.

But it play major role in production of Poly-hydroxyalkonoates which is biodegradable plastic). PHA has various properties such as biodegradability, biocompatibility and non-linear optical activity which give rise to intensive research to use these polymers in high value added applications such as packaging material.

Several factors which affect the economics of PHA production is the substrate cost. Sweet whey attains approximately 5% lactose, 0.2% lactic acid and 1% protein as well as fats, minerals and vitamins



(Fig 1 .life cycle of biodegradable plastic)

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METHOD:-

For the production of biodegradable plastic from the cheese whey following requirements are there which includes bacterial strain like T. thermophilus HB8 and media which is basal rich medium.

There is a skimming takes place from the pasteurized milk after skimming Ultrafiltration is carried out for whey concentrate. Facultative up stream process of substrate is further carried out with whey permeate .

The following requirement such as lactose, glucose and galactose can be provided.

Method For Production Of Biodegradable Plastics From Cheese Whey:

I. Bacterial Strain and media:

T. thermopiles HB8 was grown in basal rich medium, For PHA production under nitrogen limitation, cultivation was carried out in 2 liter Erlenmeyer flasks containing 700 ml mineral salt.

II Determination Of lactose glucose and glucose

Take 2ml of growing culture in different time intervals and centrifuged at 6000 xg for 15 min at 40c using a commercial kit, determine the lactose residue. Then, hydrolyze the lactose to D-glucose and β-galatose in the presence of β-galactosidase. D- Galactose is oxidized by nicotinamide adenine dinucleotide (NAD) to galactonic ac

Biomass Determination:

Cell Concentration, defined as dry weight of cells per liter of culture broth. For this, 10ml of culture broth rapidly Cooled to 40c, filtered under vacuum and rinsed with an equal volume of cold 10mm MgSo4.

The filtered were dried for at least 43hours at 800C until stable
weight has reached.

PHA extraction and estimation:

The efficient production of biodegradable plastic depends upon cost of substrate used. It depend upon quality of Source we used. In conclusion, it is concluded that.:

(i) When the concentration of Lactose is 3g/l and % of whey supernatant in medium is 6. Then the required PHA content
13.3%.

(ii) When the lactose concentration in medium is 6 g/l and % of whey supernatant is 12, then the PHA content is 22.4%.id.

PRODUCTION OF BIODEGRADABLE PLASTICS FROM CASSAVA STRACH:

Cassava is also a major product which is used in the production Biodegradable Plastic. It is one of the richest sources of starch. The roots of cassava contain up to 35% starch, soluble carbohydrates and fats that make starch extraction from cascara very easier.

During the bioconversion, cassava starch is converted into lactic acid by bacteria and then there is a polymerization of the lactic acid by the thermochemical reactions leading to the production of biodegradable plastics Cassava is one of greatest raw material used because it is nontoxic, biodegradable and biocompatible. In today's world, 66% of the global biodegradable plastic is based on the starch. Cassava is mainly a vegetatively propagated shrub.

Starch can constitute two polymers i.e amylose and amylopectin. Amylose can contain about 20-30% and amylopectin contain about 70-80% of the total amount.

Research on starch-based materials has been widespread in recent years with many university and laboratories. High amylose content in starch signifies lower gel strength and gel stickiness and on the other hand, high amylopection level provides a better binding power. Nigeria is currently, the only country which is world's largest producer of cassava with an estimated annual production of about 39 million metric tons of tubers (Udensi, 2009)Raw material: cassava Cassava starch has been expanded under the very extrusion conditions. It has a bulk density, Due to this a little modification is required so that the moisture content can be increased. Cassava starch can be expanded in moulds, at 200-2400c for 1-3 minutes. source of starch in tropical and subtropical regions, cassava is promising raw material for the production of Biodegradable Plastic in these areas. The plastic made from cassava show various beneficial properties (Srioth, 2006).

METHOD:

Materials used in this production can be obtained from local market such as cassava tubers, vegetable oil, filter cloth, plastic wrap, aluminium foil, chemicals such as glycerol and ethanol. Equipment required are vacuum oven, drying tray, magnetic stirs, centrifugation. Cassava starch has been expanded under the very extrusion conditions.

It has a bulk density, Due to this a little modification is required so that the moisture

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content can be increased. Cassava starch can be expanded in moulds, at 200-2400c for 1-3 minutes. As a major source of starch in tropical and subtropical regions, cassava is
promising raw material for the production of Biodegradable Plastic in these areas (Avella, 2005).
Starch extraction from cassava:
The cassava tubers are available in the local markets worldwide. These tubers need proper washing so as to remove any unwanted particles. These tubers are then peeled off to makes a fine mash.

In the mashed mix, high volume of the clean water was added, removed the fibre from mash by sieving the mash through the muslin cloth .

Sedimentation of starch particles can be done by the centrifugation. Washing of starch can be done to obtain a fine, odourless and clean starch. Dried the starch and removed the unwanted particles. Boiled the solution on hot plate and then after some time removed from hot plate.

Passed he solution roll mill. The obtained product is biodegradable plastic. The summary of this process can be understood from the following flowchart Flow chart showing production of biodegradable plastic from cassava (Rewritten after Avella Cassava is mainly a vegetatively propagated shrub mainly for its starchy tuberous roots.

The biodegradable plastic formed from the cassava starch is very efficient and environmentally friendly.

Based on different experiments, the researchers had found that plastic made from cassava starch acquired the mechanical properties of a biodegradable plastic. The product also confirmed its biodegradability in way of degrading faster compared to commercial plastic.

BIODEGRADABLE PLASTICS FROM BANANA PEEL:-

Banana peel has been found to be a suitable raw material for the production of biodegradable plastic. It can be used to create plastic products with high biodegradable capacity. Banana becomes a best raw material for plastic production due to its fast production, high starch content, its fsat growth cycle and universal availability. The raw or green banana has higher starch content as compared to yellow fruit (Rossell, 2002).
Bioplastic made from banana peel has various desirable properties such as low cost of production, easy availability and degradability.

According to the Packaging Bulletin magazine's report, it has been proved that banana starch is the suitable and important raw material for synthesis of biodegradable plastic. Banana peel contain starch which can be used to produce propane-1,2,3triol which is as an
additive used to improve plasticity and elastic behavior of material (Manimaran, 2016).

Growth cycle of banana is fast and it is the basic reason for the industries to use banana most as a raw material. Plastic made from
banana peel exhibit same properties as the plastic made by petroleum manifest. However, the biggest difference between plastic manufactured from banana peel and one produced by petroleum is that, the latter of Bioplastic is completely non- toxic, once it is degraded it can be used in various fields such as fertilizer (Mooney, 2009). There is a high content of starch in green banana.

It is needed to reduce the starch level in raw peel before the banana converts it into the sugar, which inturn can be used to make bioplastic.

The green plant peel can have a maximum of 40% of starch. Hence, over 30 million tons of banana peels are thrown away annually worldwide. These peels can be used for the plastic production. Banana peels have also been reported to be a thermoplastic bio-resin for bio composite development (Koller, 2005). Such bio-composite materials have found applications in a number of industrial processes.

Method To Obtained Biodegradable Plastics From Banana Peels:
Used material:
This process is an easy approach in development of bioplastic as it uses following simple material and equipment
- Blender
- Oven
- Banana peels
- Sodium hydroxide (Solid)
- Petridish
- Sodium metabisulfate
- Hydrochloric acid
- Beakers
- Gauze pads
- Lab weights
- Flask
- Beakers

The method is divided into two steps first is preparation of banana peel and other one is

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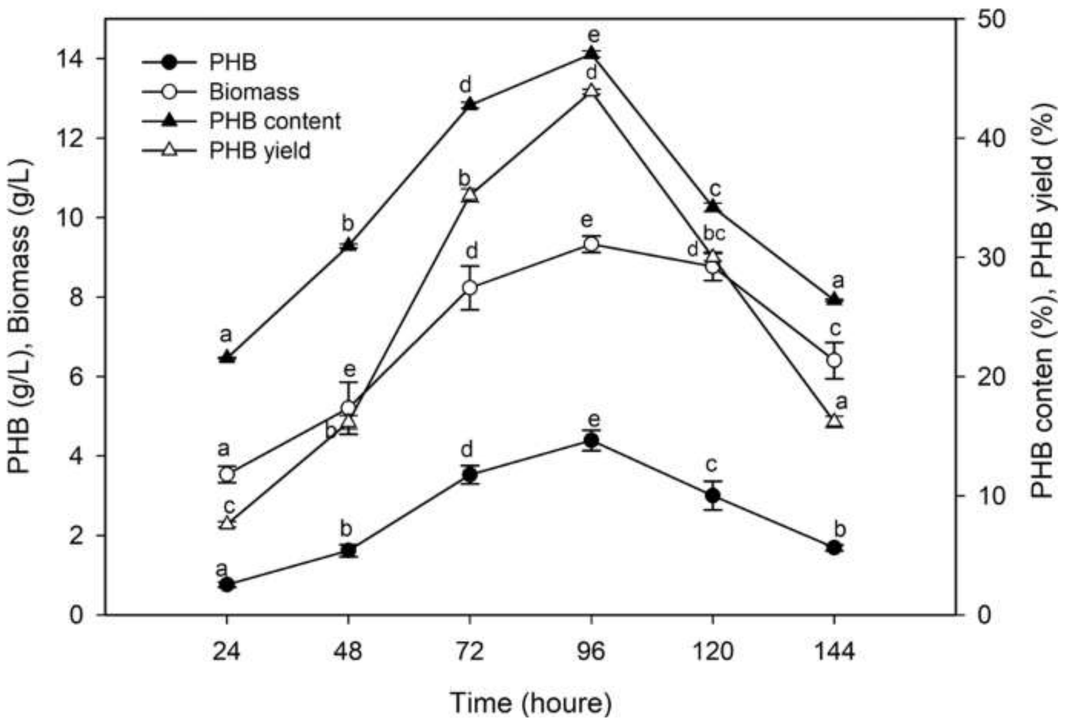
production of biodegradable plastic from thebanana peel. In preparation, banana peel taken from the nearby area and cut into small pieces and further procedure can be done .

Effect of time on biopolymer production:-

The fermentation process for PHB production by P. xiamenensis had a direct relationship with bacterial growth The significant production of PHB and bacterial biomass increased gradually until 96 h of incubation at the beginning of the stationary phase of growth, corresponding to 46.05% of the PHB content (% of biomass) and 43.9% of the PHB yield (% of the substrate), with a productivity of 0.046 g/L/h

The change in PHB content with growth was initiated after 24 h of incubation (21.53% of biomass), and this value increased gradually to 42.77% of biomass after 48 h and reached a maximum value after 96 h. It was observed that increasing the incubation time to a value above the optimum led to a decrease in PHB production reaching 26.40% of the biomass and 16.9% of the substrate, with a productivity of 0.011 g/L/h after 144 h of fermentation.



(Fig no 2 . effect of biopolymer production)

Effect of initial pH on biopolymer production

To determine the optimum pH for PHB production, the experiment was performed at pH values from 6.5 to 9.0 for 96 h of incubation . The highest PHB accumulation was achieved at pH 7.5 to 8.0, while the PHB accumulation was dramatically reduced outside this range. The maximum PHB accumulation (4.41 g/L) and bacterial biomass (9.26 g/L) were recorded at pH 7.5, with an increase in PHB content (47.62%), PHB yield (44%) and a productivity of 0.046 g/L/h.

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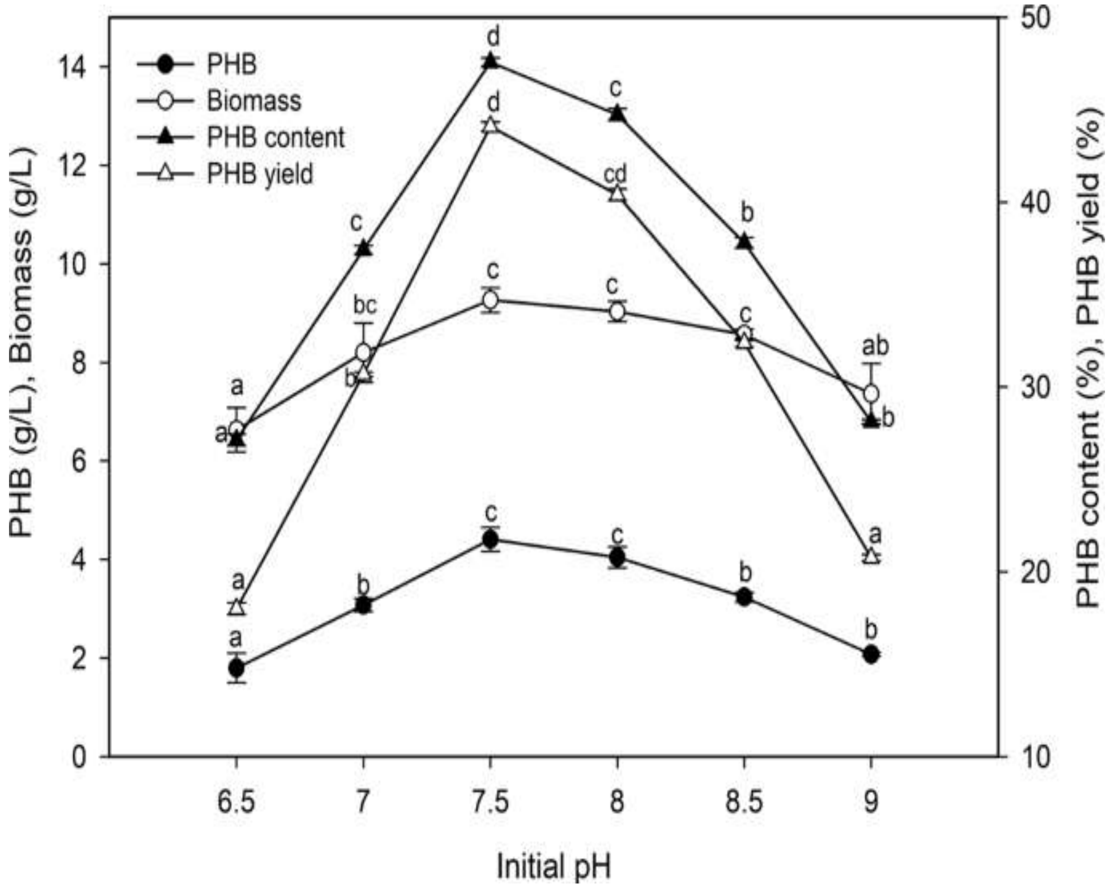

(Fig no 3.Effect of initial pH on biopolymer production)

Effect of pH value on the biopolymer production by P. xiamenensis. Mean ± standard error (n = 3) were presented. Vertical bars indicate the standard errors of the means. Means followed by different letters are significantly different at $P < 0.05$ according to the Tukey's HSD test.

Effect of temperature on biopolymer production:-

To determine the optimal temperature for PHB production, the fermentation process was performed in the range of 25 °C to 45 °C. Bacterial growth and PHB production were strongly influenced by incubation temperature

The optimum temperature for PHB production (4.38 g/L) and biomass production (9.23 g/L) was 35 °C, which reflected the PHB content (47.45%) and PHB yield (43.8%), with a productivity of 0.046 g/L/h.

The fermentation parameters were decreased beyond the optimal temperature value. The PHB concentration (3.73 g/L), biomass (8.90 g/L), PHB content (41.91%), PHB yield (37.3%) and productivity (0.038 g/L/h) were recorded at 40 °C.

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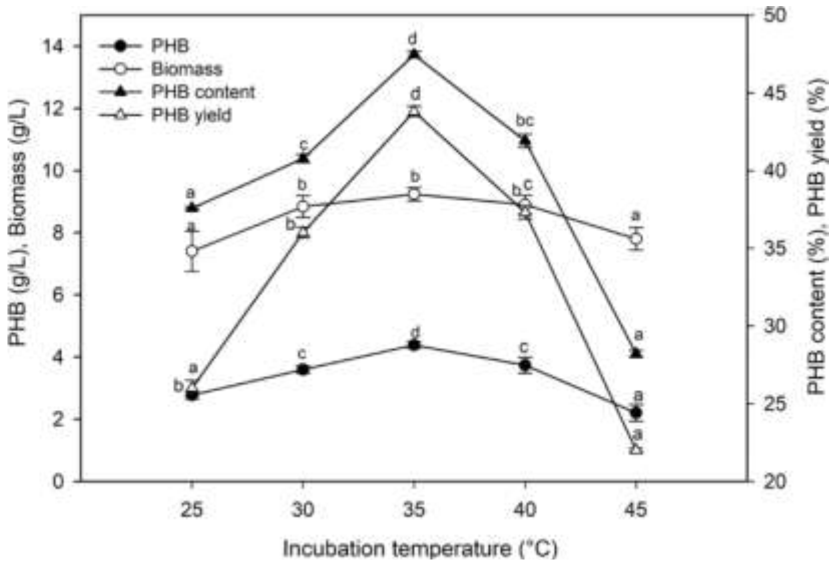


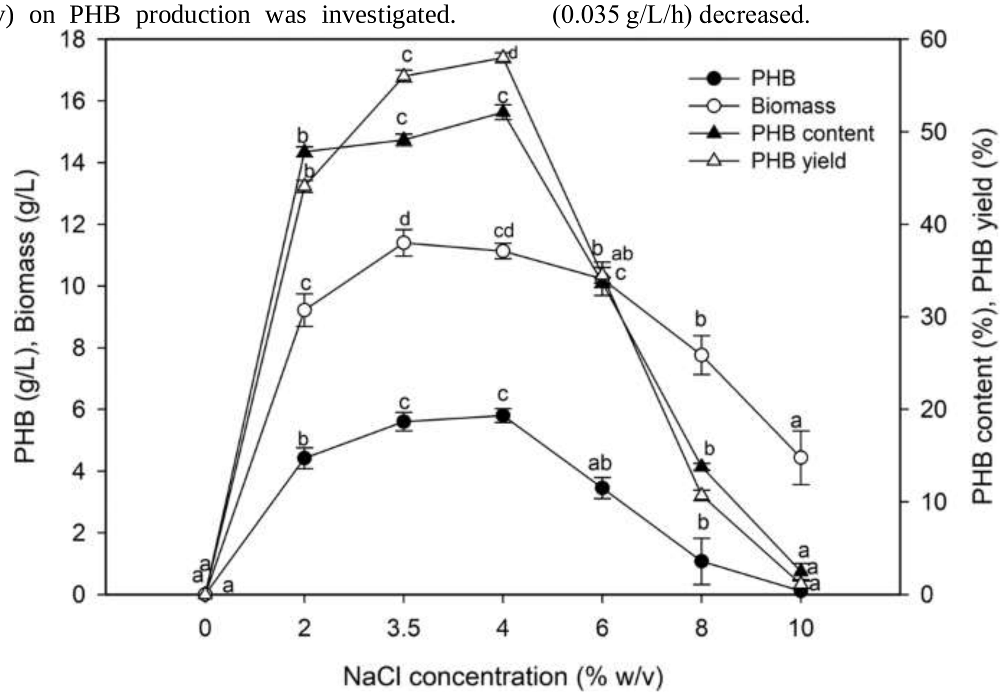
(Fig no 4Effect of temperature on biopolymer production)

Effect of temperature on the biopolymer production by P. xiamenensis. Mean ± standard error (n = 3) were presented. Vertical bars indicate the standard errors of the means. Means followed by different letters are significantly different at $P < 0.05$ according to the Tukey's HSD test.

Effect of NaCl concentration on biopolymer production:-

The effect of salt concentration (0% to 10% w/v) on PHB production was investigated. The optimum growth of marine P. xiamenensis was observed at 3.5% NaCl, while a slight increase in PHB (5.80 g/mL) was observed at 4% NaCl, resulting in a PHB content of 52.11% and a PHB yield of 58%, with a productivity of 0.060 g/L/h

The increase in the salt concentration above the optimum value was unsuitable for the fermentation process, where at 6% salt, the bacterial biomass (10.23 g/L), PHB concentration (3.45 g/L), PHB yield (34.5%), and productivity (0.035 g/L/h) decreased.



(Fig no 5 Effect of NaCl concentration on biopolymer production)

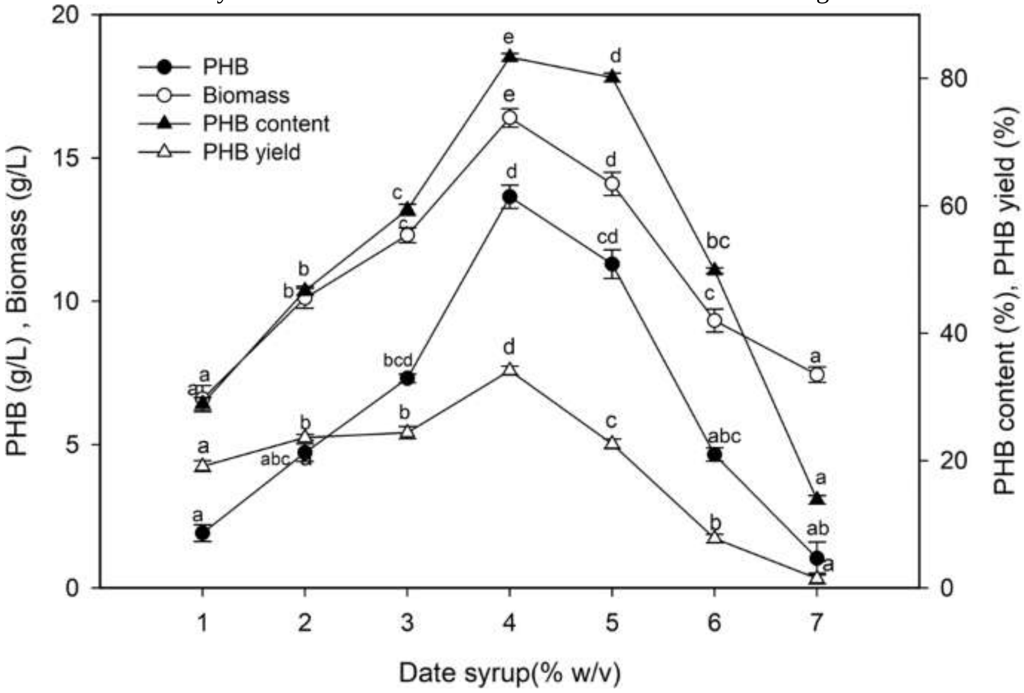
Effect of NaCl on the biopolymer production by P. xiamenensis. Mean ± standard error (n = 3) were presented. Vertical barsindicatethe standard errors of the means. Means followed by different letters are significantly different at P < 0.05 according to the Tukey's HSD test.

Effect of date syrup concentration on biopolymer production

The high cost of refined substrates such as glucose used in PHB production is a major incentive for the development of renewable materials. This experiment was performed to evaluate the efficiency with which P. xiamenensis uses date syrup, an important industrial waste in Saudi Arabia.

Date syrup contains a high concentration of fermentable sugars (79.5% total sugars, with 42% glucose, 35% fructose, and 7.4% sucrose), indicating its utility as a medium in the fermentation production of PHB.

The bacterial biomass (16.40 g/L) and PHB concentration (13.65 g/L) were optimal with 4% (w/v) date syrup, with a 2.36-fold increase in PHB concentration (Fig. 7). The PHB content and productivity increased to 83.23% of the biomass and 0.142 g/L/h, respectively, while the PHB yield (34.12% of the date syrup) decreased, compared with those observed for glucose.



(Fig no 6 Effect of date syrup concentration on biopolymer production)

Effect of date syrup concentration as a cheap carbon source on the biopolymer production by P. xiamenensis. Mean ± standard error (n = 3) were presented.

Vertical bars indicate the standard errors of the means. Means followed by different letters are significantly different at P < 0.05 according to the Tukey's HSD test.

II. CONCLUSION:-

The future of microbial/organic production of biodegradable plastic is very promising. As day by the solid waste in form of various plastics is piling up worldwide and there is no technology only available for its readily degradation, the biodegradable plastic can solve the problem of bulk requirements at domestic and industrial levels.

At industrial levels, two bacterial strains have been mainly used for the production of bulk biodegradable plastic. These strains are namely the Bacillus licheniformis and Bacillus megaterium. In 100%

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