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Bioplastic from Waste: A Short Review

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ABSTRACT: Bioplastic plays an important role in our environment as it is compatible and eco-friendly when compared to plastic bags. Bioplastic are made of organic waste produced from environment and it disintegrates faster than plastic as they are made of chain of polymers which takes billions- millions of years to disintegrate. Plastic made our environment poisonous, aquatic animals to die and many more. Environmental friendly plastic is made of many organic wastes like banana peel, sugarcane bagasse, newspaper, shrimps etc. Bioplastic mostly utilised in food packaging so that they are edible to humans and doesn't cause any disease and disintegrates fast. Bioplastic is helpful to mankind and useful to reduce environmental pollution.

Keywords: Plastic, environment, waste, pollution, packaging

INTRODUCTION

For most of our history humans used stuff which they found in nature to make the items we would have liked. But the invention of plastic fully altered our world. It's cheap, sterile and compatible. But this wonder of technology got hazardous to mankind. Plastic has drenched the environment, it has conquered the animals we eat and now it's finding its way into our bodies. It is hard to get through that how necessary plastics became to our everyday lives (Edgar and Edgar, 2009). Plastic is made from polymers – which are long repeating chains of molecule groups these kinds of polymers can be found in nature. Polymers can be recreated by breaking down crude oil into components and rearranging them, we can form new synthetic polymers. Synthetic polymers have extraordinary traits. They are light weight, durable and can be moulded into almost any shape. Not a time – consuming manual work, plastic can be easily mass- produced and its raw material is available in vast amounts and incredibly cheap, and so the golden era of plastic began. Bakelite was used in mechanical parts, PVC for plumbing, electric gears and cases, acrylic is a shatter resistant alternative to glass and nylon for stockings and war equipment. Today almost everything is least partly made from plastic our phones, computer, furniture, appliances, houses and cars (Kaiser *et al.*, 2018). Plastic has become a revolutionary material rather than that it became trash. Coffee cups, plastic bags or stuff to wrap and throw edibles. We are not thinking enough about these things. Since synthetic polymers are so durable, plastic takes between millions years to breakdown. Only 40% plastic out of 100% used for packaging purpose (Kaiser *et al.*, 2018). Six billion tonnes of plastic is waste which is recycled, burnt and most of the part is still around (Geyer *et al.*, 2017). A lot lands up in the ocean which harms eight million tons of aqua culture. If same condition continues its will outweigh the fishes in ocean by 2050. Seabirds consumed 90% of plastic (Wilcox *et al.*, 2015). Micro-plastics are pieces smaller than 5 mm which are formed due to floating wastes that is constantly exposed to UV radiation and crumbles into smaller pieces these pieces are floating in the ocean where they are more easily swallowed by all kind of marine life. This micro plastic travel up the food chain. Zooplankton eats micro plastic, small fish eat zooplankton, which are further eaten by mammals, which may someday land on our plate. Micro plastic has been found in honey, sea salt, beer, tap water and household dust around (Moskalik and Gandek 2019). We have lost control over plastic. Plastic pollution is a complicated problem. We need to be careful otherwise we would end with declined environment.

The word plastic may be a common term that's used for several materials of an artificial or semi – synthetic nature. The term was earned from the Greek plastikos, which implies "fit for moulding". They're used for cellulose, rubber, and asphalt. We have a tendency to collectively manufacture synthetic materials like covering, cars, instruments, packaging etc. They are utilised in all processes. Plastic is a material made of synthetic, semi – synthetic and organic compounds. They're ductile and might be shaped in moulds. They

are wide selected (Edgar and Edgar 2009). The main property of plastic is plasticity which is the universal property of all the materials which may deform during a method that can't be undone while not breaking but, however after we contemplate about the elastic polymers, this property happens at sucha level that their actual name is obtained from this property.

One- way plastics modified the planet was in price. It absolutely was a lot cheaper to manufacture than different materials and also the varied ways in which it can be used was staggering. They are made of polymers made of starches, cellulose, proteins and latex. Polymers are monomers made of long chains with one or additional monomers (Kaiser *et al.,* 2018).

A. Types of Plastic

Natural Plastic. These are naturally occurring materials using which plastics are made and can be turned into any shape just by using heat. Natural plastics are those substances that are released by natural methods and from natural sources. An example of this can be amber, which is used in jewellery manufacture.

Semi-Artificial Plastic. These materials in nature are changed or modified into mixture with different materials added. Natural materials from natural resources are taken and mixed with artificially synthesized materials in the lab. An example of this is cellulose ester, mixture of polysaccharide fiber and carboxylic acid and can be used to form cinema film (Chen and Patel 2012).

Synthetic Plastics. They are derived from breaking down of carbon based materials, typically petroleum, coal so their molecular structure changes. These are organic compound refineries underneath heat and pressure. Synthetic and semi artificial are often more divided into two different classes:

Thermoplastics. These are materials which will be transformed and moulded by heating and cooling process. If heat reapplied the shape can be changed again. Samples of thermoplastics are acrylic and vinylbenzene, most found at school workshops (Edgar and Edgar, 2009).

Thermosetting plastics. These are plastics that can be softened and moulded only once after being heated. If again plastics are heated they cannot be remoulded. Samples of thermosetting plastics are polyester resins and melamine formaldehyde (Alias and Ishak 2020).

Bioplastics. Derived from various materials. Bioplastic is not only made of one material its combination of different materials (Kale *et al.,* 2007). Each have different applications and properties depending on the material they are constructed from. Bioplastics is degradable and bio primarily based.

1. Bio – based: product and materials are only derived from biological entities (E.g. Biomass made of corn, sugarcane etc).
2. Biodegradable: Biodegradation could be a natural action which mixes with water, greenhouse emission and compost. The method of biodegradation depends on the external environmental stateslocation, temperature on the fabric.

'Bio based' doesn't necessarily means 'biodegradable'. The property of biodegradation doesn't depend upon the resource basis only it depends its chemical structure. Most of the plastic manufactures are created from petrochemicals. Bioplastics are made of starch which is a renewable source. Bioplastic is an emerging and growing field. However, Bioplastic development begins from a low base and yet doesn't compare significantly with the organic compound production. Worldwide consumption is mostly on packaging materials (Kale *et al.,* 2007).

Environmental effects:

Most plastics are terribly hard to degrade, the chemical structure make them sturdy and lead to slow down in degradation rate. Serious environmental threats are imposed on marine life as this light weight plastic contains toxic chemicals which are very harmful and cause various illness (Wilcox *et al.,* 2015).

Plastic is made of fossil fuel and if they are incinerated it increases carbon dioxide content of air, if they are present in landfills, they cause carbon sink and release of toxic gas methane. Most of the plastic is present on our earth which is not perishable and made of amber, which can cause pollution (Sanyang *et al.,* 2015).

Currently in our world plastic usage and pollution has been increased which indeed is causing environmental life into dangerous mode. So, as to control this fact there comes with a solution "Bioplastic" which is perishable and pollution free (Kale *et al.,* 2007).

Starch: Starch is a biopolymer. It is a soft, tasteless and white powder. It is insoluble in cold water, alcohol or other solvents. Glucose is an amylopectin and amylose. Amylose has no branches while the other form amylopectin does (Jiugao *et al.,* 2005). These glucose monomers are joined in α 1,4 linkage.

Amylose: One molecule of amylose has more than 250 glucose units. Amylose form 3D helical structure which is alike clinging. Structure formed by connecting D – glucose units by help of alpha – glycosidic linkage. Amylose is a simple structure without branches. It helps in storage and easy accessibility. Amylose also contains minimum amount of starch about 10%.

Amylopectin: Amylopectin bears the same structure as amylose but, it contains maximum amount of starch about 80%. It is not a simple chain as amylose but it is branched. Branching is in between sixth carbon is attached to the first carbon of branch. Branching occurs every 20 subunits (Singh *et al.,* 2013).

Kitchen waste Bioplastic: Kitchen waste include leftover food i.e. banana peel, potato peel and leftover wheat flour. Potato and wheat are induced by mankind in huge amount worldwide. India is the 3rd largest producer of potato. By peeling method 15-40% potato peel waste is produced as by – product by industry.

Massive amount of waste is left after industrial potato processing. Potato peel contains a minimum amount of starch, polysaccharides, lignin, polyphenols, protein and minute quality of lipids. Raw peel contains abundant moisture and carbohydrate content as compared to protein and lipid content. Recently, scientists have shaped potato peel to thin biopolymer films to store food varieties. They are eco – friendly and can bear temperature of about 200°C and are being used to store food. Biopolymers are biodegradable and useful. The only drawback films are they are not cost effective compared to plastic made of fossil fuel (Sanyang *et al.,* 2015).

Corn starch waste used for making Bioplastic. Maize is the 3rd most crucial crop grown in India. The simplest way to make Bioplastic from corn starch, few drops of corn oil and water. Heating is a crucial step.

For production of Bioplastic chemicals like HCl, Glycerol and NaOH are utilized and play different roles and their functions. As Bioplastic demand is increasing day by day and experimenting on possible biodegradable waste which is abundant, inexpensive and easily available to reduce cost too.

Cassava peel is one of the best examples of Bioplastic. Easily bio – degradable starch of cassava peel is converted into plastic using sorbitol with variation in their of 20:25:30% (wt/v of sorbitol to starch) assisted with cellulose. With good alliance between cellulose and starch the production of bioplastics could be used as an alternative for fossil based plastics which would be more environmentally friendly (Maulida and Tarigan 2016).

Pomegranate peel is designed into Bioplastic for food packaging. A student by using the extract of active agents present in the fruit shell and added to the biopolymer matrix (Jiugao *et al.,* 2005).

Rice starch: Rice is the most consumed food all over the world about 3.5 billion people every day. It is a global staple food. Plastic plays important role in commercial world. Plastics are used in different applications like toys, bottle,vehicles etc. These plastics are made of HDPE and LDPE due to which they are non-degradability and effect environment. Bioplastics are made up of starch, cellulose, proteins extracted from biodegradable waste and chitosan. The total amount of starch present in uncooked rice is 63.6% whereas brown rice contains 66.4% even they contain proteins nearly about 7%. (Jiugao *et al.,* 2005). Fifty percentage of Bioplastic made from starch extracts. Rice was ground and it is been boiled in water. The mixture is filtered and allowed to settled down after given an agitation.The beaker contains a settled starch at the bottom which, is been used to produce Bioplastic through chemical processes. There are many bioplastic examples made of starch i.e potato, corn, wheat etc.Bioplastics from renewable wastes are much more better than from long polymer chained plastics.

Agriculture waste Bioplastic: Agriculture waste is the processing residues of raw agriculture products, unsalable material produced from agriculture operations directly related to growing of crops. Waste can be of vegetables, dairy products and meat. Waste can also be solid or slurry depending upon agriculture methods. As compared to other industries agriculture to other industry produce high pollution potential for long terms. Agriculture waste for the production of Bioplastic should be rich in starch (rice, corn and potato), cellulose (sugarcane, corn husks and oil seeds, palm, soy etc) (Al-Alawi *et al.,* 2017).

Bioplastic from rice straw was first discovered. It was treated with Naviglio extractor and dissolved with the help of trifluoroacetic acid. Material obtained was with good mechanical properties. Dried and wet dumbells tensile strength and elongation at was equal to 45MPa and 61% and 10MPa and 63% was obtained respectively. Under electron microscope it showed rigid and uniform surface structure. Amorphous character is revealed by 2D X-ray diffraction. The material is decomposed within 105 days after being embedded in soil (Arun *et al.,* 2006).

During fermentation process PHB (Polyhydroxy butyrate) is accumulated which is an energy resource in microbial cells. Expensive carbon source and utilization of pure culture in the procedure lead to the high cost of production. This high cost is the problem in commercializing PHB. It have been, explored that are cheap and renewable. Using Bacillus subtilis to produce PBH is process fermentation. High glucose content present in sugarcane and pineapple waste juice is used as substrate. The major factors that can affect like temperature, pH, shaking speed, substrate to nutrient ratio and waste type were studied under aerobic condition in shake flask. In 48 hours of cultivation 16 experiments have been conducted. Results for synthesis of PHB show the significant effect on factors like temperature and agitation speed. Optimum production is different in bacteria requires different temperature. Shear force could be affected if agitated speed is not controlled that can lead to the breaking of bacterial cell (Panda, 2015).

Cellulose acetate is a biofibre utilized for production was reported from flax fibres and cotton linters. Process satisfies yield of 81% of flax fibres and 54% of cotton linters. X-ray and gel permeation chromatography was used for the structure confirmation of the Bioplastic formed. The significance of this Bioplastic is that it is not affected by acid or salt treatment but limits when it comes under alkali condition. Cellulose acetate was less affected by acid. It can be used in both food industry and medicine (Mostafa *et al.,* 2018).

Industrial Waste Bioplastic: The production of bio plastic has been successful from various industry wastes. The production of bio plastic is often very costly, so by using industrial waste products we can

minimize the cost of production. Poly- b-hydroxybutyrate is a bio – derived polymer and has a high production cost, so less costly industrial wastes were used as an alternative such as soya, molasses, bagasse and pharmaceutical wastes for its production. Alcaligeneseseutrophous was used as it gather 80% of its dry weight, high level of PHB formation was observed under aerobic condition using sesame oil (Arun *et al.,* 2006). Sugar industry waste water can also be used as nutrient source for PHB production, Bacillus Subtilis NG220 isolated from a sugarcane field area efficiently took advantage of sugar industry waste water and thus accumulate PHB (Singh *et al.,* 2013). Coffee by – products fine particles by product used in production of Bioplastic (120 meshes). This mixture is heated and pressed into primary raw material extrusion which can be further processed into bio – plastic pellets. The waste water from beer – industry can also be employed to good use as in obtaining polyhydroxyalkanoates. The methods generally include:

I. Acidogenic fermentation (acidogenesis) emission of waste is done in sequencing batch reactor for 1 to 1.6 days where the temperature is between 86.00 F and 98.60 F and the pH is 6.0, simple monomers are transformed into volatile fatty acids.

II. The fermented products feed into areactor(aerobicstage) which consists of a mixed microorganism culture with the purpose of picking out a biomass with a high polyhydroxyalkanoatesstockpilingcapacity.

III. Producingthebiopolymer (Alias and Ishak 2020).

Waste Frying Oil: 23 million tons of oil used in our country yearly out of which 3 million tons of oil is recovered as biodesel which are used vehicles which limits the pollution. WFO is complex and heterogeneous waste from restaurants, food processing units and household usages. About 90% of oil waste is collected from Europe is recycled for biodiesel production, but conversion process is been difficult (Ruth L. Eklund *et al.,* 2019). Pseudomonas putida organism is isolated from vegetable oil waste which is required for Bioplastic production highest PHA yield is observed.

Miscellaneous Waste Bioplastic: It is an infectious waste management program. It consists of many different domains medical waste, sharps, pathological waste (Liew and Khor 2015).

Newspaper: Bioplastic made from cellulose i.e newspaper discovered (Liew and Khor 2015). Newspaper is the common thing which is present in all homes, companies, institutes etc, most of the paper are dumped into these as which causes pollution. To get recycled they are transformed to Bioplastic. These bioplastics doesn't harm the environment, they are easily degradable and recycled. Bio plastic is made up from starch contents which are extracted from plant, kitchen and industrial waste. During the production of Bioplastic from newspaper, pulp is made of water and cellulose was extracted from the pulp with the application of Bioplastic from newspaper, pulp is made with the help of water, and cellulose was extracted from the pulp with the application of 1-butyl-3methylimadizolium chloride. Cellulose was converted into starch with help of group of enzymes such as cellobio-hydrolase, β-glucosidase, endo- β-1,4-glucanase. Hydrolysis of cellulose in which breakage of β-1,4glycosidic bond occurs. With the help of group of enzymes like cellobiohydrolase, β -glucosidase, endo – β – 1,4 – glucanase. Cellulose was converted into starch or glucose. Product obtained from the hydrolysis, is used in formation of Bioplastic. Starch was converted into lactic acid a non-covalent interaction produces the sheet of Bioplastic (Arun *et al.,* 2006).

Wood Chips: M Ben, T Mato, A Lopez discovered Bioplastic from wood chips. Waste products are produced from industries, construction sites. The wood is helpful to the mankind for producing the flame which increases CO_2 gas which causes greenhouse effect. The wood is an organic material it can be broken down by water, fir and air. The wood chips were converted into wood powder with help of Hydrothermal Resource Recycling System. In this process the amount of steam required according to the moisture present in the wood.Plasticization with the help of resins and plasticizers to wood powder. The plasticizers used in this process were glycerol, urea and sorbitol. After completing all the steps in this process, formation of pellets and sheets takes place (Moskalik and Gandek 2019).

Tannery trimming: Leather is an important economic sector globally in our country. Processing of raw hides to non-putrescible leather involve high volume of water, chemicals and mechanical forces to remove unwanted components to meet desired quality standards. This industry produces more solid waste and steam (Bódalo *et al.,* 2007). Tanning and many other processes are the part of leather industry. 1000kg of wet salted hides produce 200kg of leather and 700kg of solid. The solid waste produced are classified into two categories tanned (leather trimming, buffing and trimmed makeup) and un tanned waste (keratin, fleshing and trimming) (Kale *et al.,* 2007). These wastes are primarily protein rich components that face much environmental pollution. From all these waste trimming waste have content of collagen. 300,000 ton of raw trimming waste generated contains 20% v/v collagen. These raw trimming waste used for glue, gelatin and fertilizer production. Every year 800 million tons of plastic end in marine which degrades marine environment. Alternative to conventional plastic is Bioplastic which is biodegradable. Turning industrial waste into useful material. Biopolymer blend with collagen for replacing petroleum based products (Bódalo *et al.,* 2007).

Poultry feather waste: Poultry industry provides large amount of protein food in the diet as well as the waste produced from the industry is more in amount. The biomass generated is feather, blood, meat, etc. feather is the huge amount of waste produced from industry.5 million tons per year in world feather waste is produced (Bódalo *et al.,* 2007).

Most of the waste is dumped only small amount is used in feed stocking. If the waste is dumped they need large amount of area as they release large amount of metals and chemicals. Feathers contain protein keratin which is fibrous, insoluble and hardest protein in the world. It is rich in some amino acids with high nutritional potential. This feather keratin is used in bio-based material like Bioplastic. Biomass like human hair, wool and many more are used in applications of tissue engineering. Keratin biomass is used in fabrication of chitosan membrane. Alkaline hydrolysis is to be done to extract keratin from feather biomass. Keratin has been studied physical and chemical properties to make Bioplastic film using microcrystalline cellulose as nano-additive. By this the industrial potential of keratin powder is studied.

Shrimp Shells: Angelina Arora a 15 years old girl who had an idea that Bio plastic can be made from these prawn shells. This research is being heading by the professor name Nicola Everitt, who is studying this idea with the help of other fellows present in Nile University (by researchers at Harvard University's Wyss Institute). They have been in process of producing chitosan from chitin. The shrimp shellshave backbone which is calcium carbonate and which is removed by the help of acid. The acids like hydrochloric acid removes the calcium carbonate and which is removed by the help of acids (Bódalo *et al.,* 2007, Liu *et al.,* 2020). The acids like hydrochloric acid removes the calcium carbonate present on the shrimp shells and which is removed by the help of acid. The acids like hydrochloric acid removes the calcium carbonate present on the shrimp shells which are dispersed in the water. The alkali which helps in the formation of long chain leads to formation of Bioplastic. The alkali which can use in this is NaOH to neutralize the process of the solution. By processing all these steps there occurs formation of Bioplastic sheets is obtained (Singh *et al.,* 2013).

Date palm: Fruit which is one of the largest production and consumption in South Africa (Chao and Krueger2007). A tree can live upto 60 years yielding 400kg of fruit/year. The waste is immature fruit, spoiled and rotten utilized for Bioplastic production (Al-Alawi*et al.,* 2017). By help of the chemicals like PHA and other plasticizers the waste is converted to organic and biodegradable plastic.

Tea waste: 750gms of tea is consumed in a day per person in India. There is waste production which is tea leaves. Bioplastic is been produced from this tea waste ultimate result was no waste outcome during Bioplastic production. The used ingredients are tea waste, citric acid and water. Citric acid acts as hygroscopic plasticizer in Bioplastic film whereas, tea waste makes anhydrophobic action (Liu *et al.,* 2020). One day the Bioplastic will commend the world towards packaging and many more areas by removing the plastics.

There are many more examples of bioplastics produced from waste like fish, bacteria, microalgae, fungal waste and some other organisms high in PHA.

Functions of different chemicals:

Glycerol: Plasticizers are a significant class of low molecular weight, non-volatile compounds that are regularly used as additives in the polymer industries. The main role of these kinds of substances is to enhance the flexibility and process ability. They reduce the tension of deformation, hardness, density, viscosity and electrostatic charge of a polymer while on the other hand enhancing the polymer chain flexibility, resistance to fracture. The enormous growth in bio-plastic industry (Moskalik and Gandek 2019). A series of tests were conducted on sugar palm, starch (films to compare and characterize the effect of glycerol and sorbitol) as plasticizers on its physical and thermal features. In this study it was revealed that the type of plasticizer greatly impacts the thickness of film. G-SPS (glycerol) films displayed less thicker films than S-SPS(Sorbitol). The differences in the thickness revealed may be due to the variance in molar mass of sorbitol and glycerol. S-SPS films display lesser moisture value when set side by side to glycerol containing G-SPS films. The digital weighting scale was put to use to estimate the moisture content of the film samples.

S-SPS displayed lesser moisture content than G-SPS which may be due to the high molecular structure resembling of glucose unit to that of sorbitol, resulting in higher molecular interactions between sorbitol and the intermolecular polymer chains (Sanyang *et al.,* 2015).

Ammonium hydroxide: Ammonium hydroxide in a solution in which water was used as an extraction method for ground corn. Ground corn was soaked into ammonium hydroxide and water for 45 min where the pH level locked at 11.3 and 11.4. this technique proved to be advantageous for starch extraction at high yield in short duration of time.

In this method following steps were involved: -

1. Corn particles in ablender.
2. Groundcornissoakedinasolutioncontainingammoniumhydroxideandwater.
3. The duration of the soaking step must be 45 minutes.
4. Isolate starch after centrifugation.
5. Isolated starch is washed with water and 95% ethanol (Liew and Khor 2015).

The use of ammonium hydroxide is used in this process. Soaking time was 45 minutes and pH 11.6, the

ammonium hydroxide method gave high yield and soaking time increases product yield also increases.

Sorbitol: One of it is sorbitol that acts as plasticizer an organic solvent. This increases the mechanical properties like soft, resilent and strong. It has high boiling temperature and rigid. This prevents or decreases the intermolecular forces accumulation in the long chain. Chain mobility is increased. Sorbitol is a hydrophilic compound used in starch films resulting in improved barrier and mechanical properties (Sanyang *et al.*, 2015).

Tensile strength: Tensile strength is the ability of a material to withstand a pulling force supported by a material without any fracture when stretched, divided by the original cross- sectional area of the material. Measured in units of force that is force per unit area (Geyer *et al.*, 2017).

Tensile strength(S): F(max)/A

Advantages of Bioplastic:

1. Important advantage is derived from renewable resources i.e corn, sugarcane instead of coal.
2. Bioplastic degrade way faster than oil-based polymers.
3. Bioplastic doesn't generate toxic chemicals.
4. Reduce carbon-dioxide emission.
5. Reduced utilization of fossil fuel.
6. Bioplastic mix easier with soil as they are compostable.

Advantages of starch as Bioplastic substitute:

1. It is a good oxygen barrier in dry state.
2. It has renewability property.
3. It is cost effective.
4. It is present in abundance.
5. It is has high property of biodegradability (Edgar and Edgar, 2009).

CONCLUSION

After having a detailed study about plastics, it is well understood that they can cause a serious threat to the environment and also to humankind. Therefore, the intervention of bioplastics is very much essential and should be a major subject of research in order to protect the life on earth. Different methods of generation and applications of bioplastics has been discussed in methodology where starch and cellulose is found to have major importance.Using this the gap between the application of bioplastics and its study can be fulfilled, and the concept of bioplastics can be into application and lead the environment and research into a better future.

FUTURE SCOPE

Multiple biomaterials are available on earth or can be made in the laboratory in order to develop bioplastics using carbohydrate polymers like starch and celluose. Using such methods can improve the environment as well as provide us a better substitute to the existing plastics we have. The matter of concern is the amount of research being done on it and the actual practical outcome that is generated. There is a huge gap. Using specific methodologies, such gaps can be fulfilled and bioplastics can have an excellent future in this world as its application can not only be a blessing to the environment but also a new resource of research.

Conflict of intrest statement: The authors declare that there is no conflict of intrest

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