



Keratin Waste: Impact on Ecosystem and their Sustainable Management

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Abstract: - Keratin is a durable, insoluble, fibrous protein belonging to the large family of structural protein to form hair, nails, feathers, wool and horns. Keratin present in higher vertebrates (mammals, birds and reptiles). Keratin doesn't degrade in nature because of the tight packing of their polypeptide chains in alpha-helix structures and their linkage by disulphide bridges. Food industry especially the poultry farms, meat market, slaughter house and wool industries produces million tons of keratin waste. According to a literature review, keratin waste contributes to environmental pollution, resulting in the destruction of a valuable resource, a decrease in species diversity, and soil acidification with negative impact on ecosystem. In nature for overcome these problem keratinophilic fungi play significant ecological role in degrading keratin residues. Keratinase enzyme is an enzyme produced by keratinophilic fungus that digests keratin. The current findings suggest that keratinophilic fungi may play a key role in keratin degradation in the environment, and that Keratinase produced from keratin waste can be employed in the feed, cosmetics, and pharmaceutical industries.

Keywords- Keratin waste, ecosystem, environmental pollution, keratinophilic fungi, sustainable management.

1. Introduction

Keratin is abundantly available as a by-product from poultry, slaughter house, tanning and fur processing industries. With developing urbanization, food industries especially meat market, slaughter house, poultry farms, wool industries and leather industries produces million tons of keratin waste.¹ These industries considered as polluting industries with negative environmental impact. Very few organisms are able to degrade keratin and utilize it due to enzymatic undigested nature and their stability. So, their disposal leads to environmental problems such as air, soil and water pollution. In the World America, India, Brazil and China are main producer of keratin waste which produces millions of tons of keratin waste.²

Keratin monomers assemble into bundles to form intermediate filaments, which are tough and strong unmineralized epidermal appendages found in reptiles, birds, amphibians and mammals. It is extremely insoluble in water and organic solvents. Keratin residues represent an environment problem and act like rubber due to high resistance to degradation in nature because of high degree of cross-linkages by disulphide and hydrogen bonds. Thus, the di-sulphide bonds are responsible for the stability of keratin protein and their resistance to enzymatic degradation.³

Nature has provided the earth with a taxonomy of beneficial microorganisms. Keratinophilic fungi and bacteria are biggest group of the organisms which have the ability to degrade the keratin waste. Keratinophilic fungi play a vital role in the natural degradation of keratinized waste present in the soil. The keratinophilic fungi are responsible for the breakdown of any keratin containing wastes such as hair, nails, fur and feather and recently have attracted attention throughout the world.^{4,5}

2. Sources of keratin waste

Poultry farms, slaughter house, leather, wool and fur processing industries throw out extensive amount of keratin waste. Their disposal leads to environmental problems such as air, soil and water pollution. Every year more than 20,000 tons of feathers are produced as waste by poultry farming.⁶ The accumulation of hair also considered as keratin waste and caused many environmental problems.⁷

Around 24 billion chickens per year are killed across the world which is discarding four billion pounds of poultry feathers. The chicken feather content large amount of keratin protein.⁸ The human need of chicken, wool, fish, birds, and reptiles in the food produce mammoth size of keratin waste. These wastes accumulated in ecosystem and causing environmental pollution and adversely affect the life of people living in the nearby locality. The human nail is an important organ and primarily compost of keratin protein, containing large amounts of sulphur with several disulphide linkages. This unique keratin network structure results in a highly effective permeability barrier.⁹

The beak of the birds is composed of hard keratin with cross-linkages of sulphur.¹⁰ The horn of animals has inflexible configuration and consist hard keratin protein with sulphur cross-linkages. Their treatment in nature is very difficult due to hard keratin network.^{11,12}

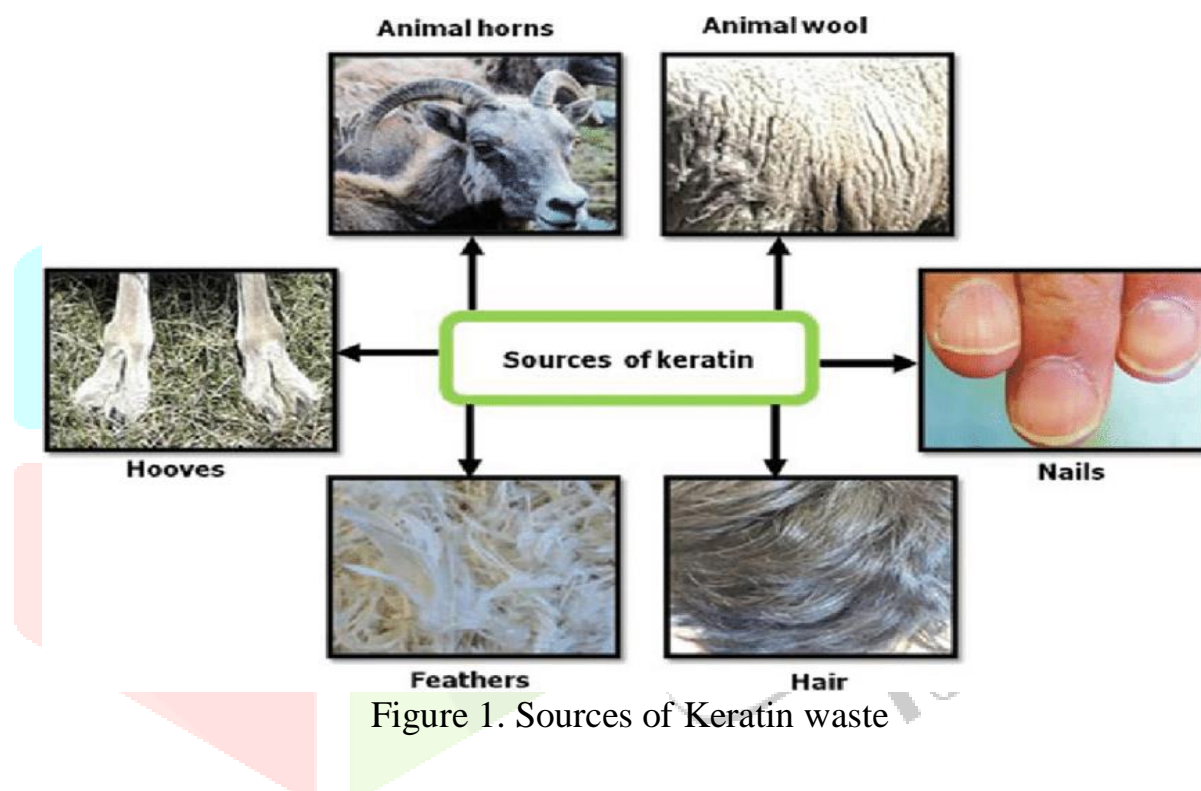


Figure 1. Sources of Keratin waste

3. Impact on Ecosystem

An ecosystem consists of all the organisms and the physical environment with which they interact.¹³ Keratin is known as major animal products such as feathers, hairs, nails, hoof, claws, skin etc. With developing urbanization, food industries especially the meat market, poultry farms, slaughter house and wool industry produces millions of tons of keratin waste which continuously accumulated in the ecosystem and causes environmental pollution and adversely affect the life of people living in the nearby locality.¹⁴ Keratins are difficult to degradation and their disposal leads to negative impact on ecosystem. The human need of chicken, wool, fish, birds, and reptiles in the food produce mammoth size of keratin waste.

3.1 Keratin waste from leather industry

The disposal of keratin waste from leather industry are most important keratin pollution source. The leather processing is responsible for adversely impact on ecosystem.^{15,16} The discharge of keratin waste from tannery industry causing serious health problems as well as air, water and soil pollution.

3.2 Keratin waste from poultry industry

Keratin waste is generated from the poultry farms in the form of feather in large quantity. Accumulation of feathers will lead to environmental pollution. Around 8.5 billion tons of poultry feather are generated worldwide each year, of which India alone produces 350 million tons.^{17,18}

3.3 Keratin waste from Slaughterhouses

Chicken feathers, mixture of bones, beaks and tissues are generated in large quantity as a waste by-product of the meat industry (slaughterhouses). As a result of the contaminated waste water generated from such industries, soil have acidified, eutrophicated, and species diversity has decreased. The conventional methods used to dispose of keratin waste are not only expensive, but also inefficient and inconvenient, however these procedures are polluting ecosystem and pose a risk to environment.^{19, 20.}

3.4 Keratin waste from barber shops

Keratin pollution is also generated by barber shops and hair dressers. Human hair is considered to be an environmental pollutant all over the world, and it is found in municipal waste.²¹ In cities, hair is often deposited as solid waste, clogging drainage systems. In rural areas, hair is thrown into nature where it slowly decomposes over several years. Inhaling large amounts of hair dust from open hair dumps can result in several respiratory diseases.²²



Figure 2. Keratin waste producing industries

4. Sustainable management of keratin waste

Keratin, which is not easily degradable by common proteolytic enzymes. It degrades by special type of enzyme are called ‘‘Keratinase’’ enzyme. Keratinase are proteolytic enzyme that digests keratin. Diverse group of microorganisms are reported to produce Keratinase like fungi (keratinophilic fungi) and bacteria. The keratinophilic fungi play significant role in the degradation of keratin waste. Keratinophilic fungi have been frequently isolated from, where they are colonizing various keratinous materials degrade them and to the mineral content in the soil.

Keratinophilic fungi grown on keratin which is a durable, insoluble fibrous protein, and forming the main structural constituent of skin, nails, hair, feathers, horns, claws, hooves, and other cornified appendages, as natural baits for keratinophilic fungi.²³

Keratinophilic fungi are of great importance for two main reasons. Firstly, these fungi play a very important role in ecosystem functioning and degrade three a major portion of soil keratin waste together with bacteria and actinomycetes, which otherwise would have been a major pollution problem. Secondly, these fungi are potential producers of industrially important enzymes the keratinase.

Keratinases are proteolytic enzymes that degrade keratin and an inducible enzyme that is synthesized only when an inducer (keratin) appears in the environment. All keratinases are secreted from a keratinophilic fungus. So, keratinophilic fungi helps in degradation of keratin. Keratin materials have high protein content,

consisting of at least 17 essential amino acids which can be used for purposes such as nutrition in animal feed or fertilizers, medicines and cosmetics.

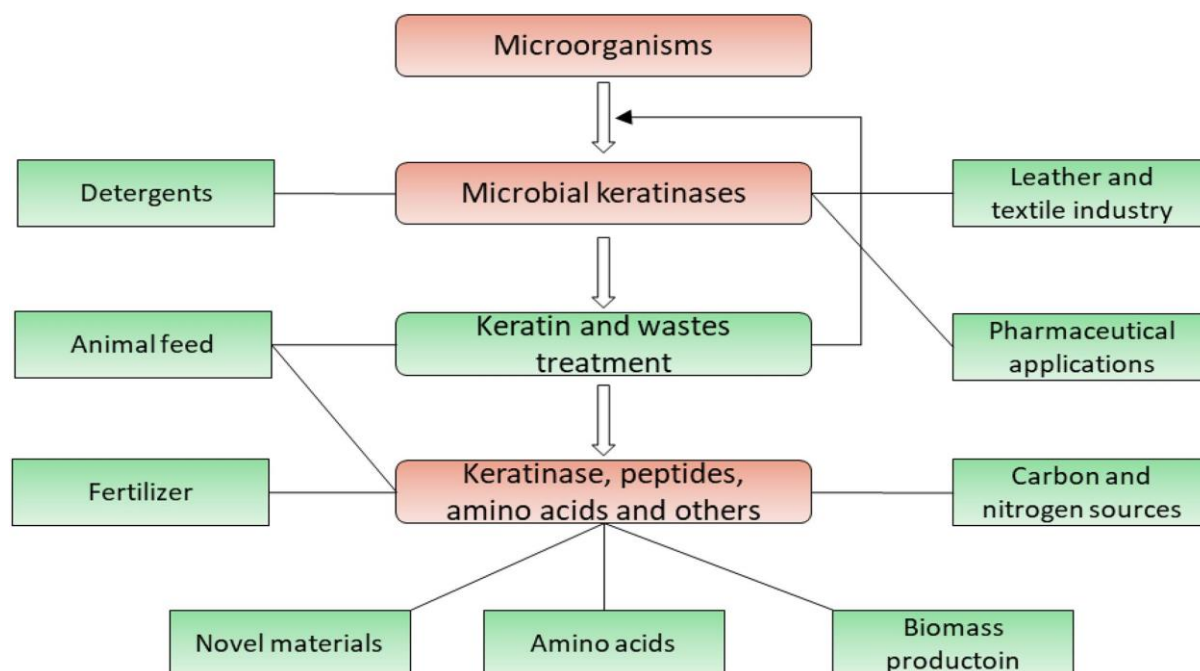


Figure 3. Applications of keratin

The use keratin protein for medicinal purposes is clearly documented by Zheng et. al.²⁴ Keratin also does not contain harmful compounds and can be used directly to make creams, cosmetics, shampoos, hair conditioners and pharmaceutical products. The soluble keratin protein would have applications in tissue regeneration, wound healing, cell seeding, diffusion, and drug delivery.²⁵ Keratin protein which obtains from feathers used to produced fibers, films, hydrogels, nanoparticles for the purpose of medical. food, cosmetology, textile, composite, agriculture and other industries.

5. Conclusion

This study aimed to understand the impact of keratin waste on the ecosystem and how insoluble, indigestible keratin waste degrade in the environment. Based on the findings of the study, the keratin waste seems to be difficult to degrade in the environment. Every year food industries especially poultry farms, slaughter houses and wool industries produce mammoth size of keratin waste. Due to the stability of keratin, a large amount of keratin waste accumulated in the ecosystem and lead to environmental problems. Only Keratinase enzymes have capability to degrade keratin materials. The present study shows that Keratinolytic microorganisms have ability to produce Keratinase enzyme. So, these microorganisms have great importance in degradation of keratin waste and its use for improvement of livestock feed and production of fertilizers, medicines and cosmetics.

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