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RESEARCH ARTICLE

ECOLOGY AND DISTRIBUTION OF ACTINOMYCETES IN NATURE– A REVIEW

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ABSTRACT

Actinomycetes are the Gram-positive bacteria and represent a ubiquitous group of microbes widely distributed in natural ecosystems around the world. Therefore, evaluation of their distribution is important in understanding their ecological role. Actinomycetes are widely distributed in different habitats and involved in important processes. They are the most abundant organisms that form thread-like filaments in the soil. Actinomycetes constitute a huge extent of the microbial populace in many soils, and their suitable check frequently surpasses one million for each gram. Theystand out amongst the most broadly conveyed gatherings of microorganisms in nature, shaping a vast piece of the microbial population of the soil and aquatic environments such as rivers, lakes and other freshwater habitats.

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INTRODUCTION

Ecologists have long been bewitched by the huge decent diversity of organisms that live on Earth. Undoubtedly, understanding the complex patterns of this variety, and the predominant powers that control them, is a major focus of community ecology. This area of ecology has an almost exclusively above-ground focus (Mittelbach *et al.,* 2001). It is necessary to understand the ecology by studying the reciprocal relationship between organisms and their environment; thus ecology is the study of organisms in their natural home or habitat. Microorganisms are an important component of an ecosystem. Microbial ecology can be characterized as the study of the demeanor and activities of microorganisms in their natural environments (Brock, 1993). Until recently, progress in soil microbial ecology was hampered by the inadequacy of methods to characterize the vast diversity of microbial communities in soil. This is largelydue to the non-culturability of most microbial cells for example, in soil, the portion which can be cultured in the laboratory has been estimated to be 0.3% of the total number of cells observed microscopically and also due to problems involved in extracting micro-organisms from complex and variable matrices.

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In recent years, a battery of molecular methods has been developed that enable the true diversity of microbial communities to be assessed, since they do not rely on the cultivation of microorganisms prior to analysis. Microbial ecology had its beginning in the work of Koch and Pasteur. It was Pasteur who first discussed the role of the microbes in natural habitats. Koch, the medical bacteriologist, proposed postulates that provided the basis for the study of the microbes in natural habitats. Sergei Winogradsky, first provided evidence that microorganisms were responsible for a specific transformation in nature. Goals of microbial ecology (Marshal, 1992) are:

- To define population dynamics in the microbial community
- To define the physicochemical characteristics of the microenvironment, and
- To understand metabolic processes carried out by microorganisms in their natural habitat.

Actinomycetes are the most abundant organisms that form thread-like filaments in the soil. They grow as hyphae like fungi accountable for the characteristically "earthy" odor of freshly turned healthy soil (Sprusansky *et al*., 2005).The actinomycetes survive in several habitats in nature (George *et al.,* 2012) and represent auniversal group of microbes extensively distributed in natural ecosystems around the world

(Srinivasan *et al.,* 1991). They are originally soil inhabitants (Kuster, 1968) but have been found significantly distributed in a various range of aquatic ecosystem, including sediments collected from deep sea (Walker and Colwell, 1975; Colquhoun *et al*., 1998), even from greatest depth Mariana Trench (Takami *et al*., 1997; Pathom-aree *et al*., 2006). Actinomycetes are a standout amongst the most broadly conveyed gatherings of microorganisms in nature, shaping a vast piece of the microbial populace of the soil and aquatic environments such as rivers, lakes and other freshwater habitats (Goodfellow and Williams, 1983). A microorganism can live in conditions of extreme temperature, acidity, alkalinity, or chemical concentration (Dubey and Maheshwari, 2009). Most of the extremophilic microorganisms produce enzymes and antibiotics. Actinomycetes were also isolated from uncommon habitat. In alkaline soils, alkalophilic actinomycetes were isolated at (*Streptomyces and Nocardiopsis*) pH 10-12 surrounding mineral springs (Jiang *et al.,* 1993) and another species of alkalophilic actinomycetes from a soda lake soil (pH10) was described as *Bogoriella caseilytica* (Groth *et al*., 1997). In another study, *Saccharomonospora halophila* was isolated with optimum growth at 10% NaCl from marsh soil (Al-Zarban *et al*., 2002). Mevs *et al.,* (2000), published a studyon *Modestobacter multiseptatus*, a psychrophilic strain with optimum growth at temperature 11-13˚C which was isolated from transantarctic mountain soils. In 1997 Suzuki *et al.,* published a study stating that optimum growth temperature for psychrophilic actinomycetes, *Cryobacterium psychrophilum*, is 9-12˚C and did not grow at a temperature higher than 18˚C which was isolated from Antartica soil. Further, a study was published in 2000 by Zakalyukina *et al.,* stating that acidophilic actinomycetes were isolated from acidic forest and peat soils, mainly *Streptomyces* and *Micromonospora.* Dey and Chaphalkar (1998) isolated thermophilic *Streptomyces spp.* from slime and water samples of meteoritic crater. This isolate grew on agar at 55˚C, with only 18 hours' sporulation time. It produced protease at 55˚C and the enzyme was stable up to 85˚C at 7.5-12 pH range. Few rare thermo-tolerant actinomycetes isolated from desert soils of Mojave Desert, California belonged to genera *Microbispora*, *Nocardia*, *Microtetraspora*, *Amycolaptosis*, *Actinomadura* and *Saccharothrix* were reported by Takahashi *et al*., (1996). These actinomycetes grew at temperature up to 50˚C.

Distribution in nature

Soil: Actinomycetes constitute a huge extent of the microbial populace in many soils, and their suitable check frequently surpasses one million for each gram. The soil is likewise the most productive wellspring of segregates, huge numbers of which deliver antibiotics and other valuable metabolites *in vitro*. Delegates of more than 90% of actinomycete genera have been isolated from soil (McCarthy and Williams, 1990). The soil is the widest habitat of actinomycetes which can be found in a wide range of soils (Williams *et al.,* 1989). It has been watched that the actinomycetes in the soil become connected to surfaces, for example, plant deposits or fungal hyphae (Mayfield *et al.,* 1972), and they may have a vital natural part in the degradation of litter in soil (Goodfellow and Simpson, 1987). The biggest groupings of actinomycetes can be found in the organic horizon (Hagedorn, 1976). In many soils, *Streptomycetes* involve 1-20% of the aggregate feasible tally (Kutzner, 1986), and 64-97% of the cultivable actinomycetes (Wang *et al.,* 1999). The more arid the soil and cooler the atmosphere, the higher the extent of the *Streptomycetes* (Xu *et al.*, 1996). In coniferous backwoods soil in Finland, actinomycetes stayupto 5 % of the feasible tally (Elo *et al*., 2000). Actinomycetes may assume a part in advancing plant development, through control of root pathogens or in some aberrant route, since a few species can produce antifungal compounds (Hamby and Crawford, 2000). Actinomycetes are industrially utilized as biocontrol specialists (Raatikainen, 1995). Then again, Streptomyces spp. is the causative operator of potato scab, a plant malady, which makes critical money related misfortunes the horticultural group (Takeuchi *et al*., 1996).A broad examination was completed by Mansur (2003) to explore the event and a conveyance of actinobacteria distribution from dry area, Saint Catherine, South Sinai, Egypt. Two hundred eightactinobacteria were isolated and identified from ten soil samples. The existence of high population of actinobacteria was significantly correlated ($P<0.001$) with organic matter and soil moisture contents. The predominant genus in all soil sample was *Streptomyces*(n=74), followed by *Nocardia* (n=50), and other isolates were identified as *Actinomadura, Nocardiopsis, Psudonocardia, Rhodococcus, Micromonospora* and *Steptosporangium*.

Aquatic habitats: Watery environment varies highly from earthly natural surroundings; biological characteristics of watery actinomycetes and their delivery are expected to be not the same as those of soil actinomycetes. They have been isolated from freshwater as well as marine environments. Research on the biodiversity of aquatic actinomycetes is not basic for major studies, yet important for practical exploitation (Jiang and Xu, 1996). Moran *et al.,* (1995) demonstrated that in seaside swamp residue, actinomycetes represented 2-5% of the microbial group, and were an indigenous populace. Every now and then, actinomycetes likewise grow in drinking water tank influencing the water quality by causing soil smells, which are because of their generation of volatile secondary metabolites, for example, geosmin and methyl isoborneol (Wood and Goss, 1985). Actinomycetes from aquatic habitats have gotten nearly little consideration. Mostly genera present in water are *Actinoplanes, Micromonospora, Nocardia, Rhodococcus, Streptomyces,* and *Thermoactinomyces.* An assortment of genera has been isolated from seawater and marine sediments including*Streptomyces, Micromonospora, Microbispora* and *Nocardia* (Shejul, 1998). In the current years, marine microorganisms have turned out to be imperative in the investigation of novel microbial items showing antimicrobial, antiviral, antitumor, and anticoagulant and cardio active properties (Austin, 1989). These active compounds may fill in as a model framework in the revelation of new medications (Bernan *et al*., 1997). A sum of 90 actinobacteria were isolated from 11 unique type of marine sponges that had been collected from seaward Ras Mohamed (Egypt) and from Rovinj (Croatia) and reported by Abdel - mohsen *et al.,*(2010).

Roots: Actinomycetes exist in the rhizosphere and rhizoplane of numerous plants, and Frankia strains are nitrogen-fixing endophytes in root nodules of different non-leguminous bushes and trees.There have been shockingly couple of quantitative investigations, but R: S ratios in light of feasible tallies are regularly low fruitless soils, while those in sand rises extended from 16 to 50. The endophyte seen in the root nodules of non-leguminous plants was for some time suspected to be an actinomycete, which was confirmed by its underlying isolation from *Comptonia* root nodules (Callaham *et al.,* 1978). The confirmation of saprophytic action of Frankia in soil is as yet obscure, however, Baker (1988), recommended that it is very liable to be suited for life as a soil saprophyte. Figueiredo de Vasconcellos *et al*., (2010) surveyed the actinobacterial population from the rhizosphere soil of *Araucaria angustifolia*. They isolated 103 isolates of actinobacteria by using five different culture media for the comparison of their effectiveness in isolation of actinobacteria. A total of 25 soil samples were collected from rhizosphere regions of different plants from a farm in Sungai Ramal Luar, Malaysia. These samples were treated with and without calcium carbonate. About 300 actinobacterial isolates with different morphology were obtained by Yi Ng and Amsaveni (2012). A study was undertaken to isolate biologically diverse actinobacteria from rhizosphere soils of medicinal plants collected from different locations of Yercaud Hills belonging to Eastern Ghats of Southern India, and 20 different isolates of actinobacteria were obtained. Further, the actinobacterial populations were also correlated with soil nutrients (Nithya and Ponmurugan, 2012).

Composts and moldy fodders: These environments contain awidespread various populace of actinomycetes whose expansion has been energized by clammy, aerobic and impartial to alkaline pH conditions. Microbial activity, in general, is dynamic by the high organic natural content and self-warming outcomes in the progression from a mesophilic to thermophilic microflora. The superiority of actinomycetes is established, and can even be specifically seen as a surface blossom, named 'fire tooth', in fertilizers (Williams *et al*., 1984). Mixing to keep aerobic conditions is an imperative piece of the composting procedure and has suggestions for inspecting since the actinomycetes populace should, consequently, be uniformly distributed. In moldy fodders, which incorporate substrates with altogether different properties, e.g., straw and grain, localized areas of actinomycetes activity are more probably have developed, with the likelihood of the aerobic and thus acidic region which should be avoided during sampling. Actinomycetes are found in fertilizers and feed, particularly in self-warmed feed or grain (Lacey and Crook, 1988). Amid the beginning times of treating the soil or self-heating, mesophilic species are available, but these are replaced by thermo-tolerant species like *Streptomyces albus* or *Streptomyces griseus* and with growing temperature, the genuine thermophilic species have their spot (Goodfellow and Simpson, 1987).Thermophilic strains were isolated from fertilizers in numbers going from 10^3 to 10^5 cfu/g dry weight and in the moldy hay from 10^5 to 10^7 cfu/g dry weight (Goodfellow *et al.,* 1987). The strains were distributed out to groups, viz., *Streptomyces thermovulgaris, Streptomyces thermoviolaceus, Streptomyces macrosporus, Streptomyces megasporus* and *Streptomyces thermolineatus* (Goodfellow *et al*., 1987).

Air: The capacity of actinomycete spores to go about as respiratory allergens have given the principal impulse to ponder on the recuperation of actinomycetes from the air. This connection between actinomycete spores and respiratory disease has produced a considerable measure of data on numbers and types of actinomycetes found in air (Lacey, 1988).

Various habitats: Actinobacteria are known to occur in typical conditions, as well as in extreme environments, which are described by acidic/basic pH, low or high temperatures, saltiness, high radiation, low levels of accessible dampness, and nutrient supplements (Zenova *et al.,* 2011), so the various physiology and metabolic flexibility of extremophilic actinobacteria let them remain due under hateful and bad conditions (Shivlata and Satyanarayana, 2015). Recovery of actinomycetes from the assortment of environments beyond those discussed above can more often than not by straightforward adjustment of routine systems. There are various circumstances where the idea of the natural surroundings required the improvement of specific procedures. Actinomycetes have been found in the digestive organs of arthropods, gut substance and fecal matter of millipedes, and the natural movement of the millipedes is responsible for acquiring a surface population of actinomycetes in the soil (MacCarthy and Williams, 1990). *Streptomycetes* constituted 15 to 50% of the aggregate of gut microflora. *Micromonosporapropionic* is able to do breaking down cellulose from the gut. *Rhodococcus* spp was isolated by Ivshina in 1981 from oilfield groundwater (McCarthy and Williams, 1990).

Role of actinomycetes in ecosystem

Actinomycetes are found in considerable number as a main component in most soils. In most ecological systems, they are saprophytic with a major role in soil organic matter decomposition (Arai, 1997). Actinomycetes are an ecologically important group, which play a significant role in several biological processes such as biogeochemical cycles, bioremediation (Chen *et al*., 2015), bio-weathering (Cockell *et al*., 2013), and plant growth improvement (Palaniyandi *et al.,* 2013). According to Goodfellow and Williams (1983), actinomycetes play an essential biological part in biodegradation of plant litter, especially in the unmanageable lignocellulose segment. Since they remain as dormant spores, sporangia or resting cocci, actinomycetes will automatically germinate in the occasional presence of exogenous nutrients (Mayfield *et al*., 1972). Apart from nutrient availability, there are other environmental factors that could affect the growth of actinomycetes such as soil temperature, pH and moisture content (Goodfellow and Williams, 1983). In rhizosphere soil, actinomycetes are capable of producing antibiotics and other beneficial metabolites. Therefore, they have a possibility in influencing the rhizospheric pathogens. Getha and Vikineswary (2002) stated the possibility of Streptomyces spp., as a biocontrol agent against fungal pathogens especially in commercial crops. Potential in biocontrol aspect also proved in other study by Vercesi *et al*., (1992) which reported that *Streptomyces* spp. isolated from grapes have antifungal activity against pathogenic yeast and fungi from the same habitat. On the contrary, there are some species of *Streptomyces* regarded as pathogen such as *S. turgidiscabies* which causes erumpent scab lesions on potatoes in Hokkaido, Japan. This species was isolated from soil (Miyajima *et al*., 1998). Additionally, Park *et al*. (2003) stated that the potato scab disease was created by other species of Streptomyces *(S. luridiscabiei, S. puniciscabiei and S. niveiscabiei).*

Conclusion

Actinomycetes are known to exist in nature like terrestrial soils, aquatic habitat, as well as in extreme environments, which are having acidic/basic pH, low or high temperatures, saltiness, high radiation, low levels of accessible dampness, and nutrient supplements. Hence, actinomycetes are an ecologically important group, which play a crucial role in several biological processes such as biogeochemical cycles, bioremediation, bio-weathering and plant growth improvement.

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