# Exploratory Of Actinomycetes And Its Biotechnology Applications- A Review



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## Abstract
Nowadays, antibiotic medication research is a crucial procedure to battle harmful microorganisms and developing infectious diseases to threaten people's health and well-being around the world. Novel antibiotics are now necessary than ever due to emergence of new diseases and the drug resistance than older infectious diseases generated. However, Actinomycetes are the most varied classes of filamentous bacteria, widely distributed and known for their adaptable metabolism. These bacteria's bioactive potential helps them survive even under adverse and undesirable environmental circumstances. Actinomycetes have a high degree of genetic and functional variety, and also variation in the production of secondary metabolites, which have advantages in industrial, medicinal and environmental restoration. Bioactive compounds produced from Actinomycetes are a rich source of antifungal, antibacterial, anthelmintics and anticancer agents. Actinomycetes are potential sources of novel compounds to battle multidrug resistance in pathogenic bacteria; in addition actinomycetes-derived medicines are useful in therapeutic appliances. Other role of actinomycetes such as transformation of organic soil components into hums as degrading agents, secretion of variety of enzymes that are capable of totally destroying all the constituents and are useful in the bioremediation of pesticides, toxic metals, nuclear waste, detergents, food preservatives and biofouling applications. The use of actinomycetes will likely increase in the future when integrated with gene therapy, microbial molecular development and other improvement techniques also reviewed in this paper. Applications in biotechnology and healthcare can benefit from the incorporation of modern habitats, screening and enhancement technologies. With an emphasis on actinomycetes isolates, this review paper summarizes the state of art of actinomycetes utilization in biotechnological research and offers recommendations for future study.

**Keywords:** Actinomycetes, Enzymes, Antibiotics, Metabolites, anticancer and bioremediation.
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## INTRODUCTION
During 1919 to 1939, investigation of soil bacteria and fungus has been made for the production of antibiotics for tuberculosis. In 1939, certain fungi, especially actinomycetes assessed having an effect on bacterial growth. In 1944, streptomycin antibiotic has been developed after isolating a potent tuberculosis antibiotic and actinomycin. Actinomycetes are filamentous gram-positive bacteria with a multi-step process that belong to the phylum Actinobacteria, which is one of the biggest taxonomic groupings amongst 18major bacterial lineages presently identified [1]. Actinomycetes are derived from the Greek words "atkis" (ray) and "mykes" (fungus). They produce aerial or substrate mycelium as a result of filamentous expansion. The earthly fragrance of the soil is caused by actinomycetes [2], [3]. They can be found in both marine and freshwater environments, particularly mangroves and sea-sediments. They are classified as thermophilic and mesophiles. They are also essential for the distinctive 'earthy' odour associated with geosmin, a metabolite [4], [5].

Actinomycetes are member of the phylum firmicutes class Actinobacteria. They are grouped into certain families such as Dermatophilaceae, Actinoplanaceae, Frankiaceae, Actinomycetaceae, Mycobacteriaceae and eptomyceteceae [6].

Some of the prominent genera of Actinomycetes are *Arthobacter, Actinomyces, Frankia*, and *Streptomyces.*

This review focus on the filamentous Actinobacteria, which correspond to the Actinomycetaceae family, produces a large amount of natural products (NPs) which is useful for biotechnology applications. These bacteria are critical for human health, agriculture and biotechnology because they produce a multitude of secondary metabolites, including two-thirds of all known antibiotics, as well as many anticancer, antifungal and immunosuppressive compounds [7]. They are also huge producers of enzymes that are used in industry [8]. Microorganisms produce roughly 23,000 bioactive secondary metabolites, 10,000 of which are produced by actinomycetes, accounting for 45% of all bioactive microbial metabolites, it was found [7]. With new enzymes like amylase, lipase, deoxyribonuclease, and protease, marine microbes may catalyze a wide range of metabolic reactions. Actinomycetes are one of the most important marine microbes and have a lot of potential when it comes to producing beneficial secondary metabolites [9].

The search for new medications is still a top-priority in cancer treatment. The recent emergence of multi-drug resistant chemotherapeutic drugs, as well as their unfavorable side effects, has increased competition for novel antitumor drugs that are engaged against untreatable tumors with fewer side effects and higher therapeutic efficiency [10]. Advances have recently been made on drug development from actinomycetes using elevated fermentation and screening, combinational biosynthesis and mining genomes for cryptic pathways [11]. As a result, nearly 80 years after Selman Waksman initially described the *Streptomyces* genus, and with actinomycin could be the first antibiotic derived from an actinomycetes, these bacteria remain a great source for the discovery of new antibiotics [12]. Hence, this research examined the new significance of actinomycetes in biotechnology.

## OCCURRENCE AND DIVERSITY OF ACTINOMYCETES

### Soil Actinomycetes:

Soil has typically been used to discover medicinally significant actinomycetes. Soil actinomycetes synthesize over 80% of commercially accessible secondary metabolites [11], [13]. The location and metabolic activity of Actinomycetes are influenced by a variety of environmental factors, including pH. Acidophilic and aciduric *streptomycetes* are abundant in acidic soils. However, only a few cases of to 9.5 being identified from soil near a lake. In the laboratory, most Actinomycetes act as mesophiles, with ideal growth temperature of 25$^0$C to 30$^0$C. When inoculated into soil, several Actinomycetes produce indole acetic acid in culture. In soil, Actinomycetes, especially *Streptomyces*, play a key role in antagonistic interactions [14]. Antibiotics derived from soil Actinomycetes include erythromycin, rifamycin, gentamicin and streptomycin etc [15], [16]. *Streptomyces* species is mostly being utilized by the industry for medically significant metabolites [13]

### Compost and associated materials of Actinomycetes:

In the early phase of decomposition, several mesophile Actinomycetes are productive in compost. However, obligatory and facultative psychrophilic Actinomycetes benefit from the ability to self-heat during decomposition. Animal dung is ideal for the proliferation of thermophilic Actinomycetes. *Streptomyces distaticus* and *Thermoactinomyces vulgaris* dominant in the wasted, steamed compost and its dust, but Thermonospora species grow particularly well during the second inside phase of manure preparation for mushroom farming. Micromonospora were thought to be native to the freshwater ecosystem and played a role in cellulose, lignin and chitin turnover. Actinomycetes modify the taste and smell of drinkable water, making it unpleasant to drink. At the edge of the water, plant and animal detritus can act as habitats for actinomycetes development and production of geosmin [17].

### Marine Actinomycetes:

Sea water covers a quarter of the earth's surface and is habitat to tremendous biodiversity. Only about 10% of the sea surface is coastal, with the portion being deep sea, with more than majority of it being deeper than 2000 meters [18]. Okami and Okazaki (1978) found actinomycetes and it produces novel secondary metabolites which are distributed primarily in the marine environment [19]. In 1984, *Rhodococcus marinonascene* actinomycetes

were first identified [20]. The majority of the isolates were from the genera *Dietzia, Actinomadura, Aeromicrobium, Marinophilus, Nonomuraea, Saccharomonospora, Rhodococcus, Streptomyces*, and *Williamsia* etc. Agar, Cellulose, Chitin, Alginate and other hydrocarbons have all been observed to be digested by actinomycetes from marine sources. They have also been linked to the degradation of wood that has been submerged in seawater. Under lab conditions, Actinomycetes have been found to break down cellulose, lignin and starch in sea water [21].

Many important bioactive metabolites, such as abyssomicin C and diazepinomicin have been identified from marine actinomycetes [22], [23]. Compounds with antimicrobial properties such as aureoverticiilactam, caprolactones, chinikomycins, diazepinomicin, frigocyclinone, helaquinoline, himaloycins etc. were identified from marine Streptomyces and Salinispora [24]. The chemical "arenicolide A" was found to be cytotoxic against a human colon cancer cell line HCT-116 [25]. Other previous strains produced two bicyclic polyketides, saliniketal A and B were identified in the inhibition of ornithine decarboxylase substances.

*Micromonospora* sp. L-25-ES25-008, a marine actinomycetes cultured from a sponge, was known to produce the macrolide 'IB-96212'. In relation to the A-549, HT-29 and MEL28 cell lines, the isolated chemical revealed substantial cytotoxicity against P-388 cell line [26], [27].

## ACTINOMYCETES ATTRIBUTES AND NOURISHMENTS

Actinomycetes are heterotrophic and majority are strict saprophytes, with a few forming parasitic or symbiotic relationships with other plants and animals. Actinomycetes are believed to have a part in nutrient cycling and can be aerobic or anaerobic. For example, Frankia requires unique growth media and incubation conditions [14]. Numerous actinomycetes thrive on normal laboratory media such as nutrient agar, blood agar, trypticase agar, brain heart infusion agar and starch casein agar. To induce differentiation and the generation of distinctive spores and colors, sporo actinomycetes contain specialized agents / media [Table 1]. Mycelium spores or pieces into hyphae that infiltrate the gar (substrate mycelium) and hyphae that branched fuse together on the agar surface to form a thick, leathery colony. The composition of the medium affects the colony's density and uniformity. *Streptomyces* sp. has spore chains on the aerial mycelium that are not found on the substrate mycelium. These spores are arthospores, which are regular hyphae segments with a dense spore wall and a hydrophobic sheath that may contain spin or hairs [28].

## ACTINOMYCETES ISOLATION AND CHARACTERIZATION

Actinomycetes can be isolated using a variety of methods depending on a wide range of sources and mediums as shown in Fig. 1. Samples were taken from a variety of biological environments then the diverse strains of isolated actinomycetes can be studied through characterization as predicted in Table 2 [29].

## BIOTECHNOLOGY APPLICATIONS OF ACTINOMYCETES

Actinomycetes are a distinct group of prokaryotic organisms with gross morphological, cultural, physical and biochemical characteristics. This organization has the capability to develop antimicrobials, enzyme inhibitors, Immunomodifiers, enzymes, plant and animal growth promoters [30].

### Antibiotics:

The main source of antibiotics has long been considered to be actinomycetes. Human microbial illnesses have benefited from the development of antibiotics using newer secondary actinomycetes metabolites [31]. Antitubercular medications like rifampcin and cycloserine are used to treat *Mycobacterium tuberculosis* [32].

Anthracyclines, chloramphenicol, macrolides, aminoglycosides, peptides, nucleosides and polyether's are some of the significant actinomycetes antibiotics. As a result, the need for new antibiotics or alternative strategies to tackle antibiotic resistance is increasing more and more important. One of the greatest threats to medicine is the development of antibiotic-resistant bacterial infections, particularly those caused on by the ESKAPE pathogens (*Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Enterobacter, Acinetobacter*

*baumannii and Pseudomonas aeruginosa*) [33], [34]. By the year 2050, it is anticipated that drug-resistant infections would overtake cancer as the major cause of mortality annually. Methicillin-resistant staphylococcus aureus (MSRA), which is a dangerous bacterium and bacterial cell walls are targets of Vancomycin antibiotic attacks [29].

Within Actinobacteria, *Streptomyces* is the biggest and most prevalent source of natural metabolites; nevertheless, additional actinobacterial species are showing promise in the current study. According to one study, *Micromonospora* sp. prevented the growth of biofilms in V. cholerae and quorum sensing pathways mediated by luxO and hapR, which causes other virulence factors (cholera toxin, toxin-coregulated pili and hemagglutinin/ protease A) to be down-regulated [35], [36]. Investigating various Actinobacteria sp. especially strains of *Streptomyces, Brachybacterium* and *Micromonospora*, is a plausible way to discover nontoxic antibiotics to treat *Vibrio* infections. Marine actinomycetes-derived antibiotics and extracts may still be effective resources in the investigation of anti-vibrio therapies in human medicine, even if many of these investigations have concentrated on vibrio infections in aquatic life. From crude extracts of numerous organisms, techniques have been developed for the screening, isolation, identifications and characterization of valuable bioactive chemicals and secondary metabolites [37], [38]. The discovery of novel antibiotics from actinomycetes has greatly benefited from molecular biology approaches. Numerous areas of basic research on these microorganisms have been driven by the significance of actinomycetes in industrial biosynthesis [21].

## Actinomycetes Infections:

Actinomycetes are typically symbiotic organisms that live in human mouth cavities. When they target tissue through breaks in the oral mucosa, they have the potential to cause severe infections. Although the disease is less prevalent globally, it is still present in the USA, mostly in the form of inner immunity. Furthermore, *Nocardia* sp. could be involved [29].

## Cytotoxicity:

Adriamycin, one of the compounds formed by actinomycetes, suppresses DNA replication and is used to treat cancer. Rapamymycin on the hand weakens the immune system to make organ transplants possible. Actinomycetes exhibit significant anticancer therapeutic potential, particularly those whose products have less adverse effects than traditional chemotherapy, such as salinosporamide A [39]. Adriamycin, a medicine derived from *Streptomyces peucetius*, slows DNA replication and has anticancer properties [31].

Actinomycin D, Anthracyclines (Daunorubicin), Bleomycin and Mitosanes are further potent cancer chemotherapeutics (mitomycin C). These medications were made from intrageneric isolates of *Streptomyces verticillus, Streptomyces caespitosus* and *Streptomyces peucetius* [40]. Among the marine actinomycin with anticancer potential are streptochlorin, aureoverticiilactam, cyanosporasides, actinofuranones, chalocomycin B, nonactin, komodoquinones, marizomib, thiocoraline, tetracenomycin D, strepto pyrrolidine, cyclo- (Lpro-L-Met), and butenolides are major secondary metabolites with anticancer potential from marine actinomycetes. The chemical extracts ULDF4 and ULDF5, which were derived from *Streptomyces* strains identified in Lagos, are two examples of active anticancer metabolites. Human cervical carcinoma, human gastric carcinoma, human acute promyelocytic leukemia and human breast adenocarcinoma are all targets of ULDF4 and ULDF5's cytotoxicity [41], [42]. The substances staurosporine and kigamicin, which cause apoptosis and necrosis respectively, are structurally related to ULDF4 and ULDF5.

## Xenobiotic Conversion:

A modification of xenobiotic is the structural alteration of elements not normally used by an organism's metabolism that takes place in its chemical environment. Oxidative, reductive, hydrolytic, dehydrating and condensation processes are the most typical ones in the transformation of xenobiotics. The complex processes of biodegradation of pollutants in soil and water depend in large part on the ability of actinomycetes to carry out a variety of microbiological conversions of organic molecules. The *Nocardia* and *Streptomyces* genera have the capacity to carry out extremely

selective chemical alterations of complex molecules with both natural and manmade origins. Certain insecticides can be degraded by actinomycetes. *Nocardia* strains obtained from soil were able to break down the pesticide dalapon, 2,2-dichloropropoinic acid [43].

## Anthelmintic activity:

Avermectin produced from *Streptomyces avermitilis* is a potent anthelmintic drug that has traditionally been used to treat worms, arachnids and insects [44], [45]. Ivermectin is also used to treat onchocerciasis, canine heartworm illness and mosquito-transmitted malaria [46], [47], [48]. Spectinabilin, a nematocide produced by *Streptomyces* sp. was quite efficient. *Bursaphelenchus xylophilus* is an endoparasitic worm that is prevalent in pine woods and spectinabilin suppressed its growth. The uncommon nitro phenyl-substituted polyketide metabolite is already well known for its ability to fight both viruses and malaria [49], [50]. Actinobacteria have been shown to have positive anthelmintic activity and are still a source of effective alternative treatments for a variety of conditions [49].

## Antifungal activity of Actinomycetes:

Antimycins, which were discovered in *Streptomyces* isolated from the epidermis of attine ants, restrict the passage of electrons in the mitochondrial respiratory chain [51]. Urauchimycins A and B, which were obtained from Streptomyces sp., inhibited C.albicans has the ability to distinguish morphologically at a dose of 10g mL1. C.albicans, Mucor miehei and bacteria were not inhibited by urachimycins C and D [52]. A wide range of anti-candida sp. was demonstrated by urachimycin B and its MIC values were equivalent to those of the antifungal nystatin, suggesting potential medical uses. Activity was The few existing research which concentrated on the chemical characterization of bioactive substances generated by Actinobacteria linked with attine ants recognize the potential isolation of new molecules with biological activity [51], [53], [54]. As a result, a strategy of research into the separation of bioactive chemicals from actinobacterial from attine ants would surely lead to the development of new drugs with activity against potentially dangerous microbes for humans.

## Immune-modifying drugs:

Actinomycetes culture filtrate has been used to identify substances with low molecular weight that improve immunological responses. Immune system responses may be boosted by blockers of enzymes found on the surface of immune system-related cells. Mice showed improved immunological responses to amastatin, bestatin and phenicine from *Streptomyces olivorecticuli*, *Streptomyces* sp. ME 98-M-3, and *Streptomyces lavendulae.*

Immunosuppressive medications like FR-900506 generated by *Streptomyces tsukubaensis*. In and also exhibit greater suppression against interleukin-2 synthesis, mixed lymphocyte reactions, cytotoxic-T cells, Platelet activating factor-C induction 26 and interferon [55]

## Enzyme inhibitory activity:

Cancer treatment may benefit from the usage of enzyme inhibitors [Fig. 2]. For instance, the enzyme inhibitor revistin from the *Streptomyces* sp. blocks reverse transcriptase. The retrostatin and streptonigrin that *Streptomyces* produces inhibit reverse transcriptase. Alistragin, which suppresses carboxyl peptidase B, is a substance identified in the culture filtrates of *Streptomyces griseovirdis*. *Streptomyces tanashiensi* produces the metallo-protease-inhibiting compound phosphoramidon [56].

## Biofouling:

Biofouling is an industrial corrosion and natural efficiency issue that affects the surfaces of medical equipment and implants, membrane systems, pipelines, ship hulls and several other surroundings [57], [58]. It is brought on by the unintentional production of biofilms and also results in human dental plaque, implants, digestive tract problems, stents and tubes [59]. These biofilms are to fault for prolonged wounds, chronic obstructive pulmonary diseases, cystic fibrosis and urinary tract infections [60].

In a study of 40 marine actinomycetes obtained from *Rhizophora apiculata, Streptomyces variabilis, Streptomyces althioticus* and *Streptomyces thermolineatus* had the greatest zone of inhibition and the greatest anti-biofilm activity. The strongest biofilm-inhibitory activity against *Psychrobacter celer, Kocuria rhizophila* and *Psychrobacter alimentarius* was

seen in the chloroform extract of the *Streptomyces althioticus* strain [61].

Actinomycetes isolated in the sediments of the Madeira Archipelago synthesized napyradiomycin derivatives that inhibited *Marinobacter hydrocarbonocalsticus, Micrococcus luteus* and *Pseudooceanico batsensis* biofilms by 80%. The establishment of *Mytilus galloprovincialis* larvae was also defined by biofilm inhibition without toxicology for the invertebrate. Napyradiomycins are a practical, non-toxic source for pipeline coverings and marine antifouling paints [62]. According to these findings, marine actinomycetes metabolites are effective anti-biofilm and anti-biofouling agents, which would be more cost-effective and environmentally safe than conventional techniques. An area of medical and industrial research that shows promise is the use of marine actinomycetes for anti-biofouling remedies.

## Environmental benefits:

## Role of Actinomycetes as Biopesticides agents:

Different methods for reducing pest populations became analysis goals when the amount of harmful chemicals in the environment developed. These are biological or ecological management techniques for reducing the negative effects of insect populations, especially in agriculture [63].

Actinomycetes are important for the biological control of insects, which produce chemicals that are insecticidal effective against the house fly (Muscadomestica) [64]. Actinomycetes metabolites with proven antifungal properties include validamycin A, polyoxin B, Polyoxin D and mildomycin [31], [66], [65]. These substances are very helpful since they successfully fight fungus without endangering animals. Rice blast, also known as *Pyricularia iryzaecavara*, is a disease that can be effectively treated with kasugamycin since it does not prevent protein biosynthesis in mammals [67].

Additionally, actinomycetes are crucial for the synthesis of enzymes such as Chitinase (e.g., *Streptomyces viridificans*), cellulases (e.g., *Thermomonospora* sp.), peptidases, xylanases (*Microbispora* sp.), proteases (*Nocardia* sp.), Ligninases (*Nocardia* autotrophic) etc. Originally, insects used Chitinase as a degrading enzyme [68], [69]. *Streptomyces, Vibrio, Bacillus*, and *Serratia* have been reported to have the greatest Chitinase activity among bacteria [70].

Many of the 23 Actinobacteria isolates from *Odontotermes formosanus* demonstrated suppression of both the competition. Xylaria and the termite cultivar termitomyces in a different research. Antifungal action was shown by Actinomycin D, which was derived from *Streptomyces parvulus*, against the fungus *Magnaporthe grisea, Xylaria, Valsamali, Fusarium oxysporum and Dothiorella gregaraia* [71]. Actinomycetes isolates have a lot of potential as a source for antifungal medications.



## Bioremediation process by Actinomycetes:

Another area of ongoing research is the role of actinobacterial in bioremediation, particularly in light of the growing concern among environmental activists about industrial contamination of soil and water systems [72].

Actinomycetes play a crucial role as degrading agents in the conversion of organic soil components into humus. Some actinomycetes produce a variety of enzymes that are capable of completely destroying all the lignocellulose constituents, including lignin, cellulose and hemicellulose [73]. They are efficient at attacking uncooked plant tissues and softening them for other microorganisms because of their capacity to release enzymes. Because plant biomass contains a high amount of cellulose and hemicellulose, using microorganisms that can break down these substances is a crucial role [74].

Many strains can solubilize lignin and destroy substances linked to lignin by generating extracellular peroxidase, cellulose and hemi-cellulose-degrading enzymes [75]. The majority of the degradation agents are actinomycetes and its species can survive in an oily environment [76]. In order to remove oil contaminants, we can use these bacteria in bioremediation.

Actinomycetes produce amylases beyond the cells to perform extracellular starch decomposition. Amylolytic enzyme degradation is crucial for biotechnological applications like the food industry, textile, paper industries and fermentation [77]. Cellulase is a group of

hydrolytic enzymes produced by actinobacterial that break down the glucosidic bonds in cellulose and its associated cello-oligosaccharide derivatives [78].

The ability to successfully break down pesticides and other organic contaminants has been observed in marine actinomycetes, such as those from the genera *Mycobacterium* and *Streptomyces* [79], [80]. As a result, they could be excellent choices for cleaning up organic contaminants from marine settings. It has even been discovered that some *Streptomyces* sp., especially marine *Streptomyces* like *Streptomyces albuschlorinus,* possess traits that enable efficient pesticide / herbicide activity without causing ecological damage [79], [81].

## Actinomycetes activity in industrial field:

Actinomycetales members are highly regarded in a variety of industrial applications. They are being assessed for probiotic usage in aquaculture, the creation of biofuels, and the manufacturing of substances used in the formation of detergents, polymers and other goods.

## Actinomycetes as Probiotics:

Actinomycetes are useful as probiotics because *Streptomyces* strains also have been identified to generate amylase, protease, lipase and other enzymes that aid in the host organisms digestion and nutritional absorption. Planktonic *Streptomyces* can also be used as food for animals that predominantly eat planktonic bacteria, such as shrimp, or it can be put to aquaculture feed in the form of live feed [82]. Although there are issues about the genetic exchange of intrinsic antibiotic resistance genes from Streptomyces to other bacteria, hemolytic and genetic tests on these organisms indicate that they seem to be relatively safe for marine animals. Perhaps utilizing antibiotics at sub-inhibitory concentrations can be a solution [83], [84], [85].

The substances geosmin and 2-methylisoborneol, which are synthesized by a large number of marine Streptomyces, have an “earthy” and “musky” taste that deters consumers from owning farmed seafood. The smell and taste of the *Streptomyces* containing water appear to be diminished by ozonation; however, the requirement to ozonate the water may be another hurdle to adopting *Streptomyces* in many aquaculture farms [82]. However, the utilization of *Streptomyces* and other actinomycetes appears to be a viable way to advance aquaculture methods.



## Chemical supplements:

In order to produce 4-vinylphenol, a plastics additive from cellulose, *Streptomyces lividans* was genetically modified with phenolic acid decarboxylase from other sp [86]. A further study improved the benzoate production of *Streptomyces maritimus*, enabling it to use a brand-new pathway to directly generate benzoic acid from cellulose [87]. Due to the fact, that benzoic acid is employed in a number of methods in fragrances, hygiene products, food ingredients and medicinal products [88].

## Biofuels:

The enzymes that break down carbohydrates into these simple sugars have been discovered in numerous actinomycetes, including *Streptomyces, Nocardia, Rhodococcus, Mycobacterium* and *Corynebacterium.* This destruction makes it possible to create substances like bioethanol and biodiesel, which can take the place of present ethanol- and diesel-based fuels made from non-renewable sources [89].

A number of researches have been done to support the potential of *Streptomyces* to efficiently break down cellulose and other plant biomass, making it an excellent option for the production of biofuels [90]. Thus, these monosaccharide-based fuels may be produced in large quantities [91].

Marine isolates will be taken into account as a potential source as research on actinomycetes for biofuel production progresses. Actinomycetes sp. May play a key role in the generation of biofuels in the near future, despite the fact that this application is still relatively new.

## LIST OF FIGURES

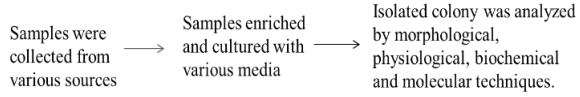


**Figure 1** Procedure for the isolation of Actinomycetes from the sample

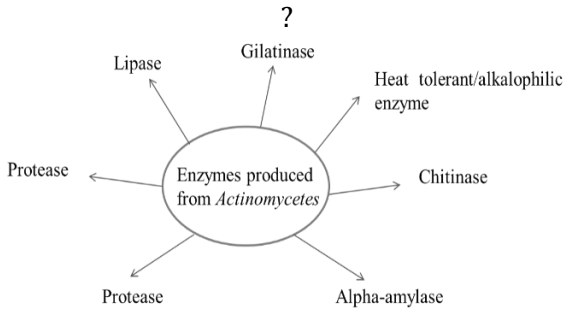


**Figure 2** Enzymes presents in Actinomycetes

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| Specific agents | Actinomycetes |
|---|---|
| Gentamicin | *Micromonospora* |
| Benzoate | *Micromonospora* |
| Oxytetracycline | *Thermoactinomyces* |
| Polymyxin | *Actinomycetes* |
| Nitrofurazone | *Streptomyces* |
| Nalidixic acid + | *Rhodococcus* |
| Bruneomycin | *Actinomadura* |

**Table 1:** Specific agents used for the growth of specific Actinomycetes

| Si.No | Sources | Culture Media |
|---|---|---|
| 1 | Lake soil | Chitin agar |
| 2 | Antarctic soil | Mineral salt (MS medium) |
| 3 | Marine soil | Starch Casein nitrate (SCN) agar medium |
| 4 | Forest soil | Starch Casein medium |
| 5 | Marine Sediments | AIM medium |
| 6 | Stream sediments and lake muds | M3 agar medium, Chitin agar medium |
| 7 | Mangroove sediments | Asparagine-glucose agar medium |

**Table 2:** Sources and media for cultivating Actinomycetes

## CONCLUSION

This paper highlights the benefits of Actinomycetes in drug discovery, cancer treatments, conversion of xenobiotic compounds, anthelmintic, antifungal, biofuel and biodegradation applications. The metabolites which are produced from actinomycetes provide an excellent area of research. Actinomycetes and their products also useful in soil biotechnology, urban waste management and environmental biotechnology. Hence, this review paper will be useful for further pharmaceutical drug discovery and other research appliances.

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## CONFLICT OF INTEREST

The authors proclaim no conflict of interest.

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