WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 7.523
Volume 6, Issue 15, 185-197. Review Article ISSN 2277– 7105

A REVIEW ON MANGROVE VEGETATION IN DIVISEEMA & MACHILIPATNAM REGIONS AND POTENTIAL APPLICATIONS OF THESE PLANTS IN NANOPARTICLE SYNTHESIS

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Article Received on 25 Sept. 2017,
Revised on 15 Oct. 2017,
Accepted on 05 Nov. 2017
DOI: 10.20959/wjpr201715-10046

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ABSTRACT

Nanoscience is a field that is making a score in research day by day and making an impact in all spheres of human life. Biosynthesis of nanoparticles by means of physical and chemical processes is highly expensive. In order to reduce the inevitable expenses in downstream processing of the synthesized nanomaterials and to increase the application of nanoparticles, the scientific community targeted the biological organisms. Plants are important, safe and easily available sources with broad variability of metabolites that may aid in nanoparticle synthesis. Recently marine plant resources have made remarkable impact in the field of pharmaceutical, industrial and biotechnological product developments owing to their rich wealth of bioactive compounds. The present review mainly focuses on mangrove vegetation in Diviseema & Machilipatnam regions and their applications in the synthesis of nanoparticles of pharmaceutical use.

KEYWORDS: Nanoscience, nanoparticles, mangrove vegetation, Diviseema & Machilipatnam regions.

INTRODUCTION

Nano technology is gaining considerable interest in recent years and is developing as an interdisciplinary field of research interspersing chemical, physical, medical and engineering sciences. The unique particle size, shape, physical, chemical and biological properties makes these particles superior and indispensible in many areas connected to the human activities. Biologically synthesized nanoparticles are gaining considerable interest in the area of biology and medicine due to their unique particle size, shape-dependence and their physical, chemical and biological properties.[1]

Nature was gifted with so many valuable resources and it also has devised various processes for the synthesis of nano materials which have contributed to the development of relatively new and largely unexplored area of research.[2]

Plants are important, safe and easily available sources with broad variability of metabolites that may aid in nanoparticle synthesis. So much of the research already proved plants as rich sources of various phyto chemicals viz., terpenoids, flavones, ketones, aldehydes, amides and carboxylic acids.[3] In addition plant extract based biosynthesis has been found to be cost effective and eco-friendly.[4] Extracts prepared from different terrestrial plants were already used for the synthesis of metal nanoparticles.[5, 6, 7, 8]

Recently marine plant resources have made remarkable impact in the field of pharmaceutical, industrial and biotechnological product developments owing to their rich wealth of bioactive compounds. Plants belonging to the marine ecosystem are extremely different from plants of terrestrial ecosystem owing to their growth under harsh environmental conditions. Mangroves are specialized ecosystems, capable of living under the influence of salt water, along the estuarine sea coasts and river mouths in the tropical and subtropical regions of the world, mainly in the intertidal zone. These plants are specialized to tolerate high salinity, tidal extremes, high fluctuations in wind, temperature and muddy anaerobic soil with the development of some adaptive morphological characteristics. No other groups of terrestrial plants survive well under such conditions. A muddy substratum of varying depth and consistency is the necessary phytogeographical condition for their growth. The plants have special adaptations such as stilt roots, viviparous germination, salt-excreting leaves, breathing roots, knee roots by which these plants survive in water-logged, anaerobic saline soils of coastal environments. Mangrove plants have a great potential to adapt to the changes in climate, rise in sea levels and to solar ultraviolet–B radiation.[9, 10, 11, 12] In view of this, the marine plants might produce different types of bioactive compounds that include polyphenols, flavonoids, alkaloids and tannins.[13, 14, 15, 16] Apart from their potential to produce variety bioactive compounds, mangroves perform a number of vital ecological functions such as nutrient recycling, maintenance of hydrological regime, coastal protection and fish production. Mangrove vegetation provides legitimate resource for socioeconomic development. It provides firewood, timber, fodder, fruits, honey, etc. to the inhabitants.

Researchers also identified mangroves as potential sources for nanoparticle synthesis.[17] Asmathunisha recorded 26 costal flora for the production of silver nanoparticles.[18] An efficient and eco-friendly one-pot green synthesis of AgNPs using extracts of mangrove leaf buds has been reported by Umashankari *et al*.[19] In addition, the synthesized nanomaterials has number of applications as evidenced by the earlier reports in which antibacterial activity of silver nanoparticles from *Rhizophora mucronata* against marine ornamental fish pathogens such as *Proteus* sp., *Pseudomonas florescence* and *Flavobacterium* sp., isolated from an infected fish, *Dascyllus trimaculatus.*[20] Anti-cancer activity of silver nanoparticles from *Suaeda monoica* was reported by Satyavani *et al*.[21]

The present review is mainly focused on Machilipatnam & Diviseema mangrove ecosystems and their potential applications in the synthesis of nanoparticles of pharmaceutical importance.

1.1. Mangroves in India & Andhra Pradesh

India has an area of 6,749 km^2 which falls under mangrove cover. It contributes to the 3.1% of the world's mangroves forest and constitutes the 4th largest mangrove area in the world. The mangrove habitats of India comprise 3 distinct zones. (1). East coast habitats with a coast line of about 2700 km facing Bay of Bengal. (2). West coast habitats with a coast line of 3000 km facing Arabian sea. (3). Island territories with 1816.6 km coast line.[22]

The coastline of Andhra Pradesh is 974 km located between 13°.24'-19°.54' N latitudes and 80°.02'- 86°.46' E longitudes. In Andhra Pradesh, about 354 Sq.km is covered by mangrove vegetation, out of which about 347 Sq.km is located in the estuarine complex of Krishna-Godavari rivers, spreading over Krishna & Guntur and East Godavari districts. The remaining mangrove area (7 Sq.km) is present in Prakasam district.[23] There are four major Indian deltas along the east coast viz. the Gangetic Sunderbans, the Mahanadi, the Krishna-Godavari and Cauvery deltas. In Mangrove forest formation and species concentration, the Krishna-Godavari delta is in the third position.

1.2. Krishna-Godavari Delta

The Krishna- Godavari delta of Andhra Pradesh is spread over an area of 585 Sq.km with a mangrove cover of 347 Sq.km. The major mangrove areas in this delta are Machilipatnam, Sorlagondi, Nachugunta, Yelichetladibba and the other important mangrove areas are Coringa, Kandikuppa, Salagondi, Yanam, Antarvedi, Repalle and Bandamuslanka.[24] Krishna district in Andhra Pradesh consists of 107 km mangrove vegetation protecting the coastal line by the uniqueness of vegetation present in between the riverine and coastal ecosystems. Krishna deltaic region covered by moderate dense mangrove forests is 63 Sq.km while that covered by open mangrove forests is 95 Sq.km.

The Krishna river is the second largest one in Andhra Pradesh. It has its origin in the western ghats at an altitude of 1,337 meters, north of Mahabaleswar, about 64 kilometers from the Arabian Sea. It flows across three states, namely Maharastra, Karnataka and eventually into Andhra Pradesh, before emptying into Bay of Bengal. There is a northern distrubutary of Krishna river at Puligadda, 60 km downstream from Vijayawada and it empties into the sea at Hamsaladeevi. There are two more distributaries of Krishna river at Gollamothupaya and Nadimeru, which are about 25 km down streams from Avanigadda and flow northward to join the sea at Sorlagondi and Nachugunta respectively. The rest of main Krishna River continues southwards to join the sea at Yelichetladibba. Mangroves are mainly prevalent around tidal creeks, channels, lagoons, tidal flats and mud flats of the three distributaries namely Gollamothupaya, Nadimeru and the rest of main Krishna river.

1.3. Diviseema & Machilipatnam Mangrove Ecosystems

Mangroves in Diviseema area lie between latitude 15° 15’ - 15° 55’N latitude and 80° 45’ - 81° 00’ E longitude. Deltaic region of Diviseema area is surrounded by northern distributary, Gollamothupaya & Nadimeru distributaries and the rest of Krishna river, which are present near Nagayalanka in Krishna district (**figure. 1**). The deltaic system is divided into three field stations viz., ‘Sorlagondi’ between Northern and Gollamothupaya distributaries, ‘Nachugunta’ between Gollamothupaya & Nadimeru and ‘Yelichetladibba’ between Nadimeru & Krishna river. The Krishna river after Nadimeru bifurcates the Krishna and Guntur districts.[25] Diviseema mangrove vegetation consists of 20 genera and 26 species of 16 families. **table 1** represents the mangrove vegetation of Diviseema region.[25]

Machilipatnam, the head Quarter of Krishna district is from 16°10’N to 16°.17’ N latitudes and from 81°09’ E to 81.13°E longitudes on the southeast coast of India and in the eastern corner of Andhra Pradesh. Mangroves in this area are present between 16° 0’ - 16° 15’N latitude and 81° 10’ - 81° 15’ E longitude.[26] Mangrove plants of Machilipatnam mangrove ecosystem were given in **Table 2**. The mangrove patches in this area were present in Gilakaladindi and its nearby villages Pedapatnam, Polatitippa and Pallethummalapalem (P.T. Palem). Sea coast is receiving a stream called Upputeru from Kolleru region at

Pedapatnam. Pedapatnam is a riverine based mangrove region. The other field stations viz. Gilakaladindi, Polatitippa and Pallethummalapalem of the region are the mangrove areas receiving sea water by tidal effect. The Mangrove Vegetation in Machilipatnam region is shown in **figure. 2**.

1.4. Mangrove based nanoparticles

Nanoscience is a field that is making a score in research day by day and making an impact in all spheres of human life. Biosynthesis of nanoparticles by means of physical and chemical processes is highly expensive. In order to reduce the inevitable expenses in downstream processing of the synthesized nanomaterials and to increase the application of nanoparticles, the scientific community targeted the biological organisms.

Mangrove plants, in spite of their occurrence in stressful environmental conditions were found to produce a wide variety of bioactive compounds and there were several reports regarding the application of these plant extracts in ethno-medical practices for treating different health disorders and ailments. There were also many reports regarding the antimicrobial, anti cancer and anti larvicidal activities of nano particles isolated from these plants. **figure. 3** shows the bio-medical applications of nanoparticles. Balakrishnan *et al*.[27] reported larvicidal activities of silver nanoparticles synthesized with *Avicennia marina* leaf extract against the larvae of *Aedes aegypti* and *Anopheleus stephensi*. Antibacterial properties of isolated silver nanoparticles from leaf extracts of *A. marina* were reported by Gnanadesigan *et al*.[28] Larvicidal properties of silver nanoparticles synthesized from leaf extracts of *Rhizophora mucronata* were reported by Gnanadesigan *et al*.[13] Antony *et al*.[29] reported the Antibacterial activities of silver nanoparticles synthesized from leaf extracts of *Rhizophora apiculata*. Antimicrobial activities of silver nanoparticles synthesized from leaf extracts of *Xylocarpus mekongensis* were reported by Asmathunisha.[18] **table 3** represents different mangrove plants and mangrove associates that produce nanoparticles of medical & pharmaceutical importance.

An important challenge in nanoparticle synthesizing technology is to tailor the properties of nanoparticles by controlling their size and shape. Using marine plants and their bioactive substances, the biosynthesis of nanoparticles extra-cellularly would be constructive if it is produced in a controlled manner related to their size and shape. Nanoparticles of desired size and shape have been obtained successfully using living organisms-simple unicellular organisms to highly complex eukaryotes. The marine ecosystem has captured a major attention in recent years, as they contain valuable resources that are yet to be explored much for the beneficial aspects of human life. The field of nano biotechnology is still in its infancy and more research needs to be focused on the mechanistic of nanoparticle formation which may lead to fine tune the process ultimately leading to the synthesis of nanoparticles with a strict control over the size and shape parameters. Therefore, it needs collaborative research of various disciplines to develop simple and cost-effective techniques to improve the quality of life.

Table 1: Mangrove plants of Diviseema coastal region.[25]

S. No	Family	Name of the Species	Vernacular name	Habitat
1.	Myrsinaceae	*Aegiceras corniculatum*(L.)	Guggilam	Tree
2.	Avicenniaceae	*Avicennia alba*	Gudammada	Tree
3.	Avicenniaceae	*Avicennia marina* (Forsk.)	Tellamada	Tree
4.	Avicenniaceae	*Avicennia officinalis* (L.)	Nallamada	Tree
5.	Rhizophoraceae	*Bruguiera cylindrical* (L.)	Uradu	Tree
6.	Rhizophoraceae	*Bruguiera gymnorrhiza* (L.)	Thoddu ponna	Tree
7.	Rhizophoraceae	*Ceriops decandra* (Griff.)	Calhasu / Thogara	Tree
8.	Euphorbiaceae	*Excoecaria agallocha* (L.)	Tilla	Tree
9.	Combretaceae	*Lumnitzera racemosa*	Thanduga	Tree
10.	Rhizophoraceae	*Rhizophora apiculata*	Ponna	Tree
11.	Rhizophoraceae	*Rhizophora mucronata*	Uppu Ponna	Tree
12.	Meliaceae	*Xylocarpus granatum*	Senuga	Tree
13.	Sonneratiaceae	*Sonneratia apetala*	Pedda kalinga	Tree
14.	Acanthaceae	*Acanthus ilicifolius* (L.)	Allchi	Shrub
15.	Plumbaginaceae	*Aegialitis rotundifolia* Roxb.	gadara	Tree
16.	Verbenaceae	*Clerodendrum inerme* (L.)	Pisingi	Tree
17.	Convolvulaceae	*Cuscuta reflexa* Roxb.	savarapu kada	Herb
18.	Fabaceae	*Dalbergia spinosa* Roxb.	Chillangi	Shrub
19.	Fabaceae	*Derris heterophylla*	silasila/ Nalla Theega	Shrub
20.	Malvaceae	*Hibiscus tiliaceus* (L.)	attaka nara	Shrub
21.	Poaceae	*Porterasia coarctata* Roxb.	Yellu gaddi	Herb
22.	Amaranthaceae	*Pupalia lappacea* (L.)	yerra uttareni	Herb
23.	Salvadoraceae	*Salvadora persica* (L.)	Gunnangi	Tree
24.	Chenopodiaceae	*Suaeda fruticosa* (L.)	Elakura	Shrub
25.	Chenopodiaceae	*Suaeda maritima* (L.)	Elakura	Herb
26.	Chenopodiaceae	*Suaeda monoica* Forsk.	Elakura	Herb

Table 2: Mangrove plants of Machilipatnam coastal region.[26]

S. No.	Family	Name of the Species	Vernacular name	Habitat
1.	Myrsinaceae	*Aegiceras corniculatum*	Guggilam	Tree
2.	Avicenniaceae	*Avicennia alba*	Gudammada	Tree
3.	Avicenniaceae	*Avicennia marina*	Tellamada	Tree
4.	Avicenniaceae	*Avicennia officinalis*	Nallamada	Tree
5.	Rhizophoraceae	*Bruguiera cylindrica*	Uradu	Tree
6.	Rhizophoraceae	*Bruguiera gymnorrihiza*	Thoddu ponna	Tree
7.	Euphorbiaceae	*Excoecaria agallocha*	Tilla	Tree
8.	Combretaceae	*Lumnitzera racemosa*	Thanduga	Tree
9.	Rhizophoraceae	*Rhizophora apiculata*	Ponna	Tree
10.	Rhizophoraceae	*Rhizophora mucronata*	Uppu Ponna	Tree
11.	Sonneratiaceae	*Sonneratia apetala*	Pedda kalinga	Tree
12.	Acanthaceae	*Acanthus Ilicifolius*	Allchi	Shrub
13.	Plumbaginaceae	*Aegialitis rotundifolia*	gadara	Tree
14.	Convolvulaceae	*Cuscuta reflexa Roxb.*	savarapu kada	Herb
15.	Fabaceae	*Dalbergia spinosa Roxb.*	Chillangi	Shrub
16.	Chenopodiaceae	*Suaeda maritima*	Elakura	Herb
17.	Chenopodiaceae	*Suaeda monoica*	Elakura	Herb

Table 3: Nanoparticles synthesized using different Mangrove plants.

S.No	Mangrove plant	Method employed	Nanoparticles	Plant part	Size (nm)	Reference
1.	*Rhizophora mucronata*	Open pot green synthesis	AgNPs	Leaf bud	60-95	[28]
2.	*Rhizophora apiculata*	$AgNO_3$ reduction method	AgNPs	Leaves	19-42	[29]
3.	*Ceriops tagal*	$AgNO_3$ reduction method	AgNPs	Leaves	30	[19]
4.	*Avicennia marina*	$AgNO_3$ reduction method	AgNPs	Leaves, Bark and Root	71-110	[30]
5.	*Sesuvium portulacastrum*, *Prosopis chilensis* and *Clerodendron inerme*	$AgNO_3$ reduction method	AgNPs	Leaves	5-20	[31, 32]
6.	*Suaeda monoica*	$AgNO_3$ reduction method	AgNPs	Leaves	50-100	[33]
7.	*Padina gymnospora* (Mangrove associate)	Polysaccharide mediated method	AuNPs	Whole	53-67	[34]
8.	*Xylocarpus mekongensis*	$AgNO_3$ reduction method	AgNPs	Leaves	5–20	[18]
9.	*Excoecaria agallocha*	$AgNO_3$ reduction method	AgNPs	Leaves	15 - 43	[35]
10.	*Avicennia alba*	$AgNO_3$ reduction method	AgNPs	Leaves	-	[36]
11.	*Rhizophora lamarckii*	$AgNO_3$ reduction method	AgNPs	Leaves	12-28	[37]
12.	*Hibiscus tiliaceus* (Mangrove associate)	$AgNO_3$ reduction method	AgNPs	Leaves	20-65	[38]
13.	*Heritiera fomes* (HF) and *Sonneratia apetala* (SA)	Sunlight mediated bio-reduction process	AgNPs & ZnO-NPs	Bark and leaves	HF- AgNPs (400 & 50) HF- ZnO-NPs (40-50) SA-AgNPs (20-30 & 70-100) SA- ZnO-NPs (400-500)	[39]

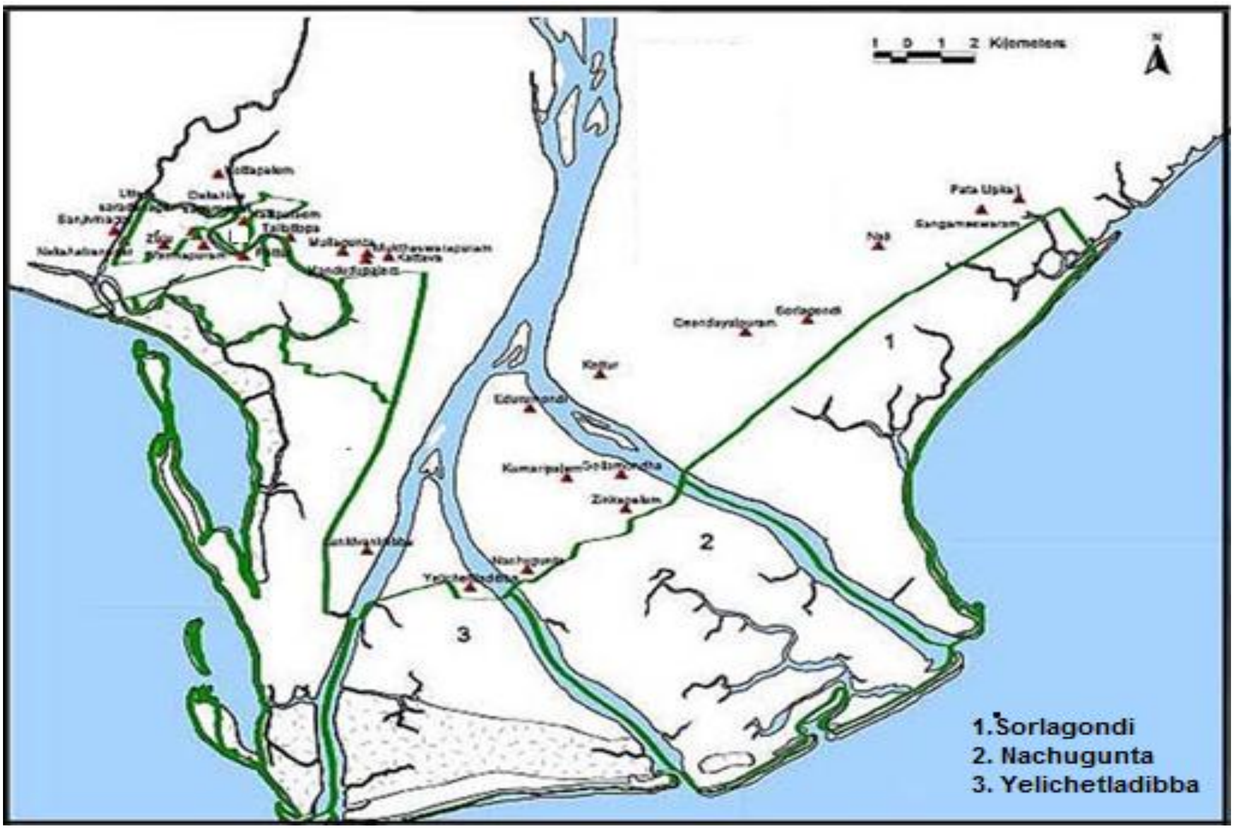

Figure 1: Map showing Mangrove vegetation in Diviseema Region.[25]

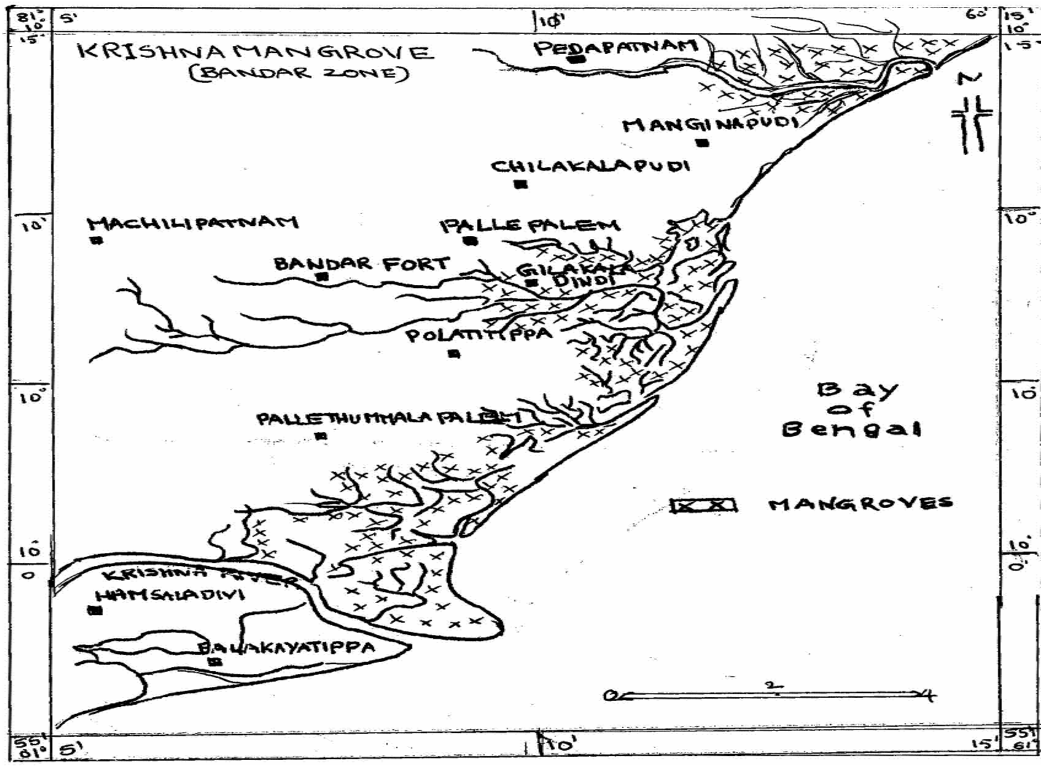

Figure 2: Map showing Mangrove vegetation in Machilipatnam region.[26]

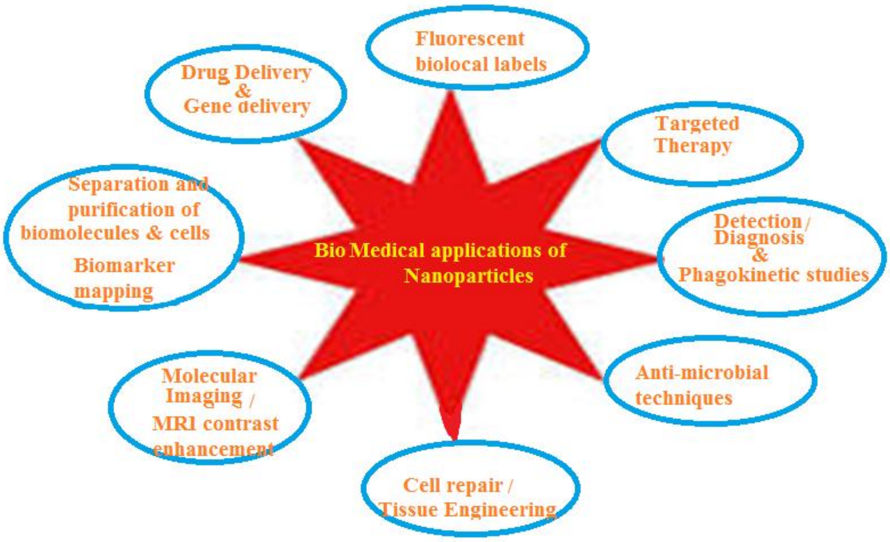

Figure 3: Biomedical applications of Nanoparticles.

2. CONCLUSION

Development of reliable and eco-friendly processes for synthesis of metallic nanoparticles is an important step in the field of biotechnology. Synthesis of nanoparticles from mangrove vegetation accomplishes the need for safe, stable and environment friendly particles since it involves diverse marine ecosystem and moreover the green synthesis of nanoparticles from mangrove species can be a potential source for the synthesis of various forms of nanoparticles and can serve as a bio-factory for nanoparticle synthesis for its application in bio medical engineering and pharmaceutical industries. Biological synthesizing methods do not involve harmful solvents and reduced downstream processing steps which shrink the cost for their synthesis.

Recently mangrove plant species were proven to be potential sources for the isolation of nanoparticles. But the studies were limited to few plants and to a particular region. Though some of the mangrove species already had been reported previously for their ability to synthesize nanoparticles, the geographical barrier and prevailing environmental factors may influence the type of nanoparticles they produce. The nature of morphological adaptations of mangroves depends on their efficiency to tolerate the environmental condition i.e. the salt content of shore-mud soils etc.

Considering this, the current review is undertaken to present the indigenous plant species of Diviseema & Machilipatnam mangrove ecosystems and their potential applications in the synthesis of nanoparticles of pharmaceutical importance.

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