Pollution and Community Health Effects
2023 Volume 1, Issue 3
DOI: 10.59657/2993-5776.brs.23.011

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Review Article
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Green Synthesis of Organic Matter to Culture the Nano-Structured Micro-Organism

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Abstract
Micro-Organism is one of the most promising and oldest inhabitants of Earth's Surface, it masters versatility and adaptability to the changing environment by proving that the Micro-Organisms are the most effective partners in our efforts for Sustainable Development. The influence of Micro–Organisms plays a vital role in Living Organisms and their diversity of activities takes away the Living Organism to various useful product productions. In line with this the era of nanotechnology, which precisely the design, production, development, and application of materials at a nanoscale (10-9m), evolves at an unparalleled rapid pace. Microbial Nanotechnology with a crucial eye in the epoch of Green Synthesis of Micro – Organism into Nano-Structured Micro-Organism (NSMO) and endeavors the novel elucidation for living organism well-being and balance the ecological and environmental factors of the earth's surface. The Green Synthesis of NSMO is also recently attracted interest in a new exciting approach that moves towards the development of Biomass Generation through its characterization. This paper reviews an insight into the culturing of NSMO through Green Synthesis for the degradation of Organic Matter. The Last Decade Literature was selected, which focuses on the Materials & Methods of Scientific Research aspects like Green Synthesis features, characterization, and applications have been discussed. The Challenges and Prospects of Potential NSMO through Green Synthesis also agreed with the intrinsic variability of the Microbial Nanotechnology System which requires a greater platform for standardization with increasing uniform characteristics. Deeper insight on Green Synthesis Pathways and opportunities from genetically stimulating research of Green Synthesis of NSMO for the future scaling–up and possible Societal Exploration and Exploitation of these techniques.

Keywords: microbial nanotechnology; green synthesis; NSOM; characterization; applications

Introduction

With the proper analysis and environmental control, Individual Household Municipal Solid Waste Containing Organic Matter constituents can be treated with the help of Micro-Organisms. Therefore, it's has been understood that the Micro – Organism Growth, Energetic and Kinetics has the potential to be a major reason for the degradation of Municipal Solid Waste. The Composting of Individual Household Municipal Solid Waste Treatment consists of mixed communities with a wide variety of Micro-Organisms which can only be accomplished by its specific type and also provides a fundamental understanding of Micro-Organism community Dynamics (Metcalf & Eddy). The application of Organic Matter Degradation and Bio-Stimulation into the Individual Household Municipal Solid Waste influenced by the Potential of Micro-Organisms and its community diversity of the Composting Process. The Role of Micro-Organism in the Degradation of Individual Household Municipal Solid Waste with its community diverse the quality of Compost.

The Carbon to Nitrogen Ratio views the concentration of Micro-Organisms through Organic Matter Degradation which results in Composting Stability over time. The Composition of Biomass Generated consists of Cellulose which acts as a best substrate for Micro-Organism Degradation. The Suitability of Organic Matter present and the Micro-Organism type in the degradation practice is essentially related to the generation of nutrient rich biomass which can be utilized for the agriculture.

The Potential Micro-Organism group plays a crucial role in Optimization of biologically Degradation substrate of Individual Household Municipal Solid Waste which also produces diverse enzymes. The utilization of Potential Micro-Organism Degradation is the most important process in the High Valued Compost Generation with its Biomass Diversity. The Micro – Organism also have a significant role to curtail the Ecological & Economical Imbalance in order to sustain the Nutrient flow from one System to another.

Micro-Organism Community & its constituents in Composting

Composting is the Process of involving the various key Micro biome which actively degrades the Organic Matter present in the Individual Household Municipal Solid Waste through Moist, Self-heating in aerobic conditions which is a natural process characterized by the Micro-Organism Community Dynamics. On Ground Realities a Microbiome is the Micro-Organism Community which present in the living Organisms and it also defines the composition of Micro-Organism Community with abundance of its members. During the Composting process, the Micro-Organisms that represents its community structure plays an active role where their diversity suggests the mechanism of Composting with an alteration in the choice and quantity of initial Organic Matter that have the ability to change the Micro – Organism Community Dynamics and the Biomass Generated Nutrient Rich Compost. The Population of Micro – Organism Diversity and Development during composting process is predominately depend on the physical Characteristics which plays a crucial role in understanding the Different Species of Micro – Organism Dynamics that indicate the quality of final Biomass Generated Nutrient Rich Compost.

The First Phase of Composting Mesophilic Phase (25° to 40°C) energy rich, easily degrades the compounds like sugar proteins are abundant and degraded with the help of fungi, actinobacteria and bacteria presence generally indicates the primary degradation which mechanically influences by regular turning and smaller in size. Other Mesofauna develops and acts as catalysts which depending on composting methods. It has been demonstrated that the quantity of Mesophilic Micro – Organisms in the origin substrate is three order of magnitude which is higher than the number of Themophilic Micro-Organisms, but the dynamics of primary degradation includes the temperature rise. The Intake Component of the Composting Pit were often heterogeneous and the initial Micro - Organism Communities maintains the low pH due to Fungal and Yeast proliferators presence and bacterial growth is reduced. Gram – Negative, alpha (α), beta (β), gamma (γ) proteo - bacteria were found primarily on Composting Sample which contains leaves and grass on the first day of composting.

Table 1: Genera retrieved within the bacterial community (Prokaryotic Diversity of the Composting Thermophilic Phase: The Case of Ground Coffee Compost Maria Papale 1, Ida Romano 2, Ilaria Finore 2, Angelina Lo Giudice 1, Alessandro Piccolo 3, Silvana Cangemi 3, Vincenzo Di Meo 4, Barbara Nicolaus 2 and Annarita Poli 2, *) Phylum/Class Genus Proportion of Total Reads Number (%).

caffA		caffB		caffE	Average	St.Dev.
Actinobacteria	Frigoribacterium	0.00	0.00	0.03	0.01	±0.02
	Sanguibacter	0.07	0.00	0.00	0.02	±0.04
	Pseudonocardia	0.28	0.37	0.58	0.41	±0.16
	Saccharomonospora	0.14	0.27	0.74	0.38	±0.31
	Saccharopolyspora	0.35	0.64	4.38	1.79	±2.25
	Streptomyces	0.07	0.00	0.06	0.04	±0.04
	Nocardiopsi	0.00	0.05	0.03	0.03	±0.02
	Thermomonospora	0.00	0.05	0.00	0.02	±0.03
Bacteroidetes	Persicitalea	0.00	0.05	0.03	0.03	±0.02
	Parapedobacter	0.00	0.14	0.00	0.05	±0.08
	Acetobacter	17.16	21.48	8.33	15.66	±6.70
	Ameyamaea	7.30	6.46	3.86	5.87	±1.79
Alpha	Brevundimonas	0.07	0.00	0.00	0.02	±0.04
	Shinella	0.00	0.00	0.03	0.01	±0.02
	Paracoccus	0.07	0.00	0.00	0.02	±0.04
	Ameyamaea	0.00	0.41	0.06	0.16	±0.22
Gamma	Bordetella	0.83	0.14	0.06	0.34	±0.43
	Lautropia	0.00	0.05	0.00	0.02	±0.03
	Orrella	0.00	0.05	0.00	0.02	±0.03
	Kingella	0.00	0.05	0.00	0.02	±0.03

Phylum/Class					
Genus	**Proportion of Total Reads Number (%)**				
caffA		**caffB**	**caffE**	**Average**	**St.Dev.**
Franconibacter	0.00	0.00	0.03	0.01	±0.02
Alcanivorax	0.07	0.00	0.00	0.02	±0.04
Pseudomonas	1.95	0.87	0.40	1.07	±0.79

The Second Phase of Composting Thermophilic Stage (40° to 80°C) hereby the degradation of Organic Matter like fats, cellulose, hemicelluloses and some other lignin takes place by Fungi and Bacteria which acts as a Thermophilic Micro-Organism. At this Phase of Composting Process, the Mesophilic Micro-Organisms were replaced by Thermophilic Micro-Organism and favors the actinomycetes Thermophilic bacteria like Bascillus spp. However, the Mesophilic Fungi may present in the external layer of the Compost Pile and reinvade the Thermophilic Micro-Organism. Towards the final Stage of Thermophilic Process, the Carbon Content Present in the Compost gets depleted and temperature gradually decrease as it prepares to come into the cooling or maturation Phase. Mutually in the Thermophilic Phase, Gram-Positive Bacteria like Bacillus spp. and actinobacteria were the most predominant strains available in the compost. These two Micro-Organisms namely actinobacteria and bacteria with huge quantity of guanine and cytosine which mainly distributed in the soil hereby they can degrade the complex mixture of polymers also. Their Micro-Organism Growth Rate, energetic and Kinetics were also decreased and have a huge capacity to degrade the less Organic Matter, Complex Organic Matter compared to other bacteria. The Final Third Phase of Composting Cooling and Maturation Phase, in which the Thermophilic Micro-Organism activity ceases due to exhaustion of substrates, the temperature starts decreasing and the Mesophilic Micro-Organisms recolonize the substrate, either originating from the spores surviving, through the spread from the protected micro niches, or from the external inoculation. In the Meanwhile, the Organisms with the ability to degrade sugars, oligosaccharides and proteins dominate, and then the Mesophilic Phase is characterized by an increase in the number of Organisms that degrade the starch or Cellulose.

During the Final Maturation Phase of Composting, it is characterized by even lower temperature below 25 °C, where the substrate quality declines and in several successive steps the composition of the Micro – Organism Community Dynamics is entirely altered. This Depletion of Substrates leads to the Micro-Organisms activity of Thermophilic ceases and Mesophilic were getting back to recolnize the Organic Matter from the spores which survive in the presence of Huge Temperature and germinate when the Temperature drops or through external inoculation from the environment or the edge of Composting pit. Usually, the proportion of fungi increases, while the bacterial numbers decline, the compounds that are not further degradable, such as lignin – humus complexes, are formed and become predominant. Since the Temperature has been decreased to a Mesophilic range of Temperature, fungi will reappear in the compost and ready for degradation of remaining Organic Matter. The Microflora during this stage plays a vital role in composting Maturation and suppress the diseases due to the phytotoxic compounds Metabolism. But still the fungi present in the soil may completely degrade the lignin that even actinomycetes and bacteria could do so.

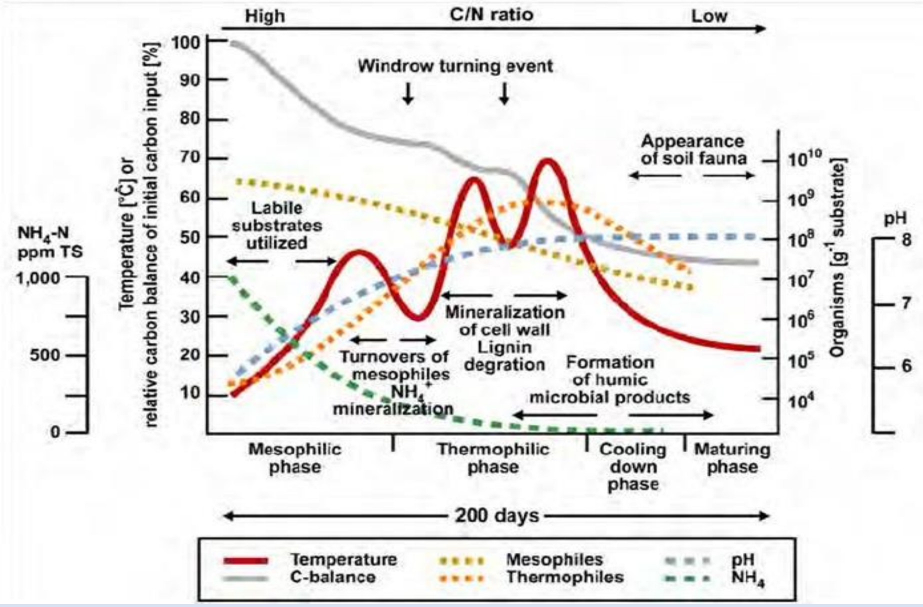

Figure 1: Different stages during composting as function of time, appearance and succession of compost biota, temperature and further processes (based on Lechner et al., 2005 and Smith & Collins, 2007).

At the closer look, the two important parameters proficiently assessed the compost quality is Stability & Maturity of Micro-Organism Community and its diverse Dynamics. The term refers to Maturity represents the compost suitability and its purpose which is particularly subjected to its biological and chemical effects while, the stability reflects directly on the biological activity, which predominantly evaluate the Organic fraction Humidification.

The Boom of Nanotechnology a Detailed Insight

The aspects of Nanotechnology comprise of structural and material modification at the nano scale and the investigation of Unique phenomena Application at the nano scale in order to produce the features of new or enhanced functionality. Nano Scale is typically defining the length between 1nm and 100nm where the three events significantly influenced the concept observation techniques and practical operations of Nanotechnology. The Nanotechnology base approaches range in the fields from Engineering and Material Science to Medicine and Biological Science. The nature of the nano material is to vary in shape and size in order to sustain the characteristics features for large spectrum utilization with significant changes. The U.S. National Nanotechnology Initiative (NNI) defines the nanotechnology as the research and development efforts at the level of atom or molecule to create structural systems which can be applicable in various aspects. In the 1980's the Concept of Nanomaterial science was popularized by the Nanotechnologist Eric Drexler in his book Engines of Creation: the coming Era of Nanotechnology, in which he stated the diverse application of Nanotechnology in Medical. Pharmaceutical, Industrial, Food and Agriculture, with a wide range and it is possible to build those materials atom by atom and imposed with desired characteristics for numerous applications in almost every area like composite materials, development, electronics, nano-electro - mechanical system (NEMS), biomedical technologies, renewable energy solutions and Environmental Remediation.

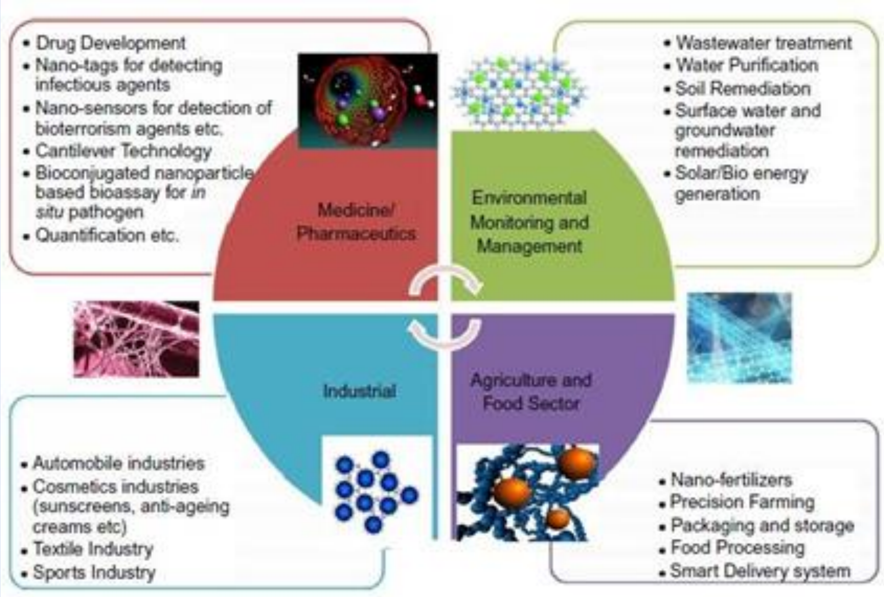

Figure 2: Nanotechnologies Application in Diverse Sectors

The characterization and manipulation tools like Scanning Tunnelling Microscope with recent advance in Transmission Electron Microscope, X- ray Diffraction; Fourier Transmission Infrared has trapped the Researcher's interest in developing nano system in a widespread manner.

Development of Nano - Microbiology

The broad areas of Science and Technology has been strengthened by the disciplines of Microbiology and Nanotechnology by delivering the novel solution for the wellbeing and maintaining the Human Health along the with Economical Environmental and Ecological Balance. It is necessary to develop the interdisciplinary approaches combining the Microbiology and Nanotechnology to combat the secondary human health, Economical Environmental and Ecological Damage. These fields were amalgamated and offer innovative sustainable solutions in a rational manner, which highlights the relationship of Nano Microbiology discipline in particularly identifying the great potential resulting from nano impacts in the areas of Microbiology. It also allows for the visualization study in the molecular assembly levels and facilitates the identification of molecular recognition and self-assembly motifs as well as the assessment. Single Molecule Imaging, Nano Scale Objects Manipulation and Spatial Organization in living Microbes Determination are the major areas of Microbiology which utilizes the Nanotechnological Approaches.

Application of Nano-Microbiology

Organic Based Nano Materials which involve the primary composite of Organic Matter with exception of Inorganic or Carbon Nanomaterial and utilize the non-covalent weak molecular interaction which tends to convert Organic Nano Matter into desired Structures including liposomes, micelles, dendrimers. The Green Chemistry principles combined with white biotechnology which really contributes to the Industrial Sustainable Process Development for Nano Manufacturing. The Micro-Organism Mediated Green Synthesis is one of the biological base nano manufacturing processes which represents a green alternative approach to physical and chemical strategies. In addition to Micro - Organism strains of bacteria, yeast, molds, and microalgae, few Micro-Organisms have shown their capability in Green Synthesis of Unique Structured materials like Bio - mineralized Nanostructures like Silicified frustules, calcified coccoliths, magnerosomes and other organic nano materials like bacterial nano cellulose, exopolysaccharide nano particles and bacterial nano wires. The Micro – Organism Mediated Green Synthesis has been extensively explored showing different advantages and features including the following:

- Green Synthesis can be performed with mild Physico-Chemical Conditions.
- Easy to handle and cultivate the Micro – Organism Cells and Cell Culture Scale-up is possible.
- Possible of in vivo tuning Nano Material characteristics by changing key parameters of Cell Culture Operational Set up or through genetic engineering tools.

The Broad application of Mirco-Organism Mediated Green synthesis can be achieved only by the unconventional choice to traditional synthetic approaches of Nano Manufacturing; many hurdles are still needed to overcome. A reduction of polidipersity of Nanoparticles, were completed by the biocapping characterization layer agents, biocapping layer removal procedure effectiveness and Nano Materials Purifications, Standardization of Micro-Organism Cell Culture protocols for reproducibility of synthesis process as well as production costs and yield.

Preparation of Nano Structure Micro Organisms

The physical chemical and biological methods are used for Synthesis of Nano Structured Micro-Organisms, in which the physical and chemical methods of synthesis have overcome certain disadvantages includes the expensive equipment's costs, high heat generation, high energy consumption and low production yield. The main drawback of physical and chemical method of Synthesis is the usage of toxic chemical which spreads several environmental problems and it also generate a need for an Economically Environmentally and Ecologically friendly solution for the Synthesis, the current focus of which is the Green Synthesis from biological routes like Micro-Organisms, Enzymes, Polysaccharides and few Degradable polymers. Due to its Simplicity, cost effective and toxic free characteristics, the Green Synthesis Methods are beneficial than the traditional physical and chemical methods, and as a result they have gained considerable importance in recent years.

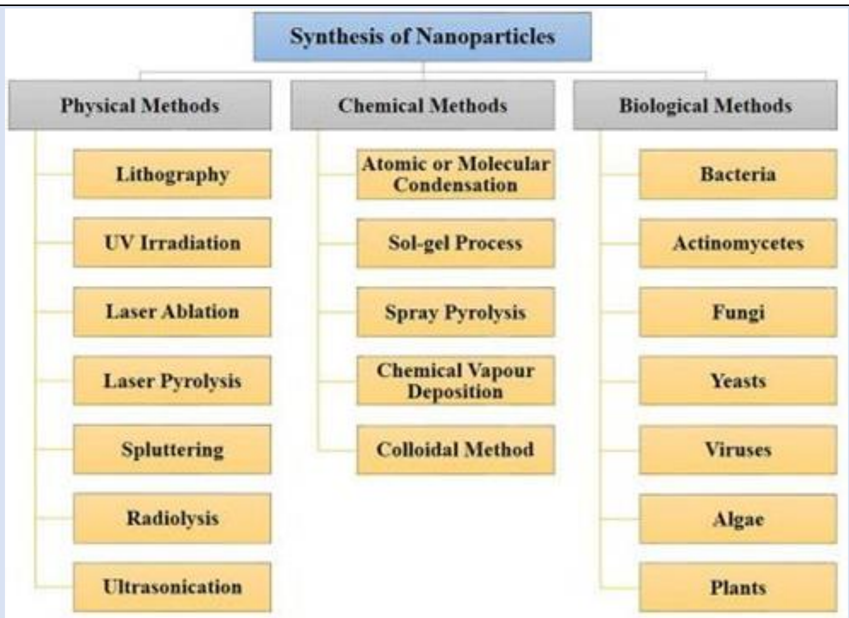

Figure 3: Different approaches for nanoparticles synthesis.

Synthesis of Micro-Organism by Spray Drying

Spray drying synthesis is the technique which defines the transformation of feed from a fluid state in to a dried particulate form by spraying the feed into a hot drying medium. In this method, a very flexible control over powder particle with characteristics of density, size, shape, dispersibility, flow, moisture can be used in a wide range where the free – flowing powder production is required. This swift dehydration of Synthesis has gained importance and has become most successful in the fields of pharmaceuticals, food processing and preservation and textile. The fluid feeds can be the suspension, solution, slurries, paste or melts. Relaxed adjustment is allowed in the spray drying synthesis method in order to encompass a broad range of experimental conditions, includes the drying of heat sensitive materials like vaccines and complex proteins. The reproducibility of spray drying synthesis enables it to be upgraded to nearly any scale of production – from a few grams of solids in lab scale, all the way up to very large instruments that can continuously produce more than 10MT of powder per hour.

Over the years, spray drying synthesis has gained importance in the nanotechnology field particularly nano-medicine, where it can be used for the good yield of particles or granules production with narrow size distribution. It is a cheaper to lyophilisation or freeze drying of Nano particle Suspension. In past few decades this technique has been proved as a crucial in the Synthesis of Nano Structured Material with a detailed discussions of its mechanism in the formation of granules and buckling of shells.

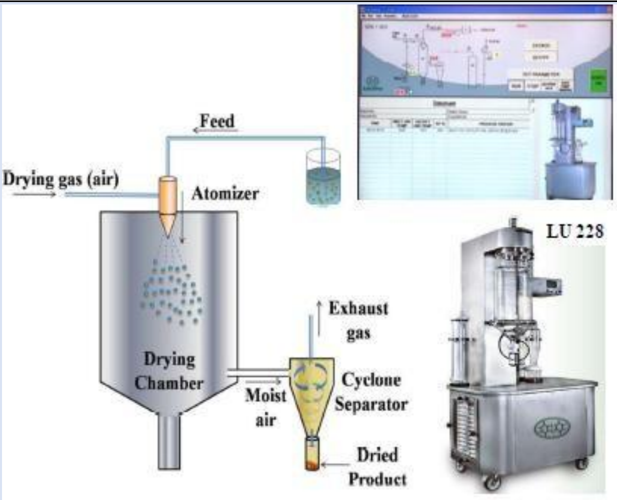

Figure 4: Schematic representation of spray dryer and photograph of the laboratory spray dryer used with the instrument control software.

Spray Drying Synthesis Process: A droplet to granule transition is described on the basis of the competitive focus which acts at various drying stages by maintaining a constant feed rate to achieve a Nano Structured narrow sized droplet distribution. Atomization increases the surface area available with a gradual disappearance of water, capillary forces which emerge as the water acts as a bridge between the particles bringing them closer. The final outcome of such process is granule composed jammed nano material. For an isolated single evaporative water droplet at a temperature, T the shrinkage in the size of the droplet, due to diffusion limited evaporation.

$$R_d(0)^2 - R_d(t)^2 = \frac{2D_v m_v}{\rho R_{gas} T}(p_s - p_\infty)\tau_d$$

Synthesis by Microbial Routes

A wide variety of bacteria, fungi, algae have been screened through numerous rigorous attempts for the synthesis process and have been explored with a route is not only inexpensive but it is also less cumbersome, time consuming, complicated and most importantly nontoxic. Moreover, with a continuous interests and attempts, it has been realized that some of the intended applications of Nano Structured Micro-Organism are feasible only through their specific biological mode of synthesis. Another interesting aspect of green synthesis is the factor that provides an excellent yield which cannot be achieved by the physical and chemical methods in a definite time span. An additional advantage is the biological route is the fact that is a bottom-up approach and is very specific in nature. The significant edge that incorporates includes less energy requirement, less input wastage and more practical control.

Bacterial Mediated Synthesis

A number of Methods has been existed for the bacteria Mediated Synthesis in which bacteria can be used as a main species and Pseudomonas, Lactobacillus, E. coli, Actinobacteria spp., and Klebsiella pneumonia were also used. The synthesis location has been evaluated to both the intercellular and extracellular, where the synthesis depends critically on the operational parameter like pH and temperature. Physical condition varies and leads to different size ranges which plays as a vital parameter for their specific application because of its novelty in terms of physicochemical properties and will more pronounced at smaller size. So, a multitude factors need to be optimized for the specific synthesis in a particular configuration. Interestingly, extracellular and intracellular synthesis have been reported in some studies that has been primarily due to specific alterations in the ionic atmosphere and temperature of reaction conditions.

Fugal Mediated Synthesis

From the recent studies it has been shown that Fungi Mediated Synthesis is risk prone, the synthesis of a ranges at both extracellular as well as intracellular locations. Fungi strains like Fusarium, Penicillium, and Aspergillus type have been reported that the synthesis of several different kinds of nano material. Fungi Mediated Synthesis possesses some additional attributes with respect to their bacterial counterparts. For illustration, the optimization for the scale up of fungi synthesis has been revealed that fungi mycelia can withstand the synthesis fluctuations of the scale up treatment in the bio reactor which perhaps plant and bacteria base extracts cannot. Moreover, fungi type also possesses a fastidious nature growth and plays a vital aspect in the formation of nano structured material through the use of fungi type.

Plants Mediated Synthesis

The most interesting biochemical and yield specific source synthesis is the plant biodiversity, in this Plants with huge genetic rich compound variability pose a number of interesting biomolecules in the structure of coenzyme, vitamin-based intermediates, and so many others which can reduce metal ions to nano structured material in a single step. Moreover, this type of synthesis can be easily conducted at room temperature and pressure, without any hard and fast technical requirements. Furthermore, plant mediated nano structured material synthesis approaches are capable to scale up easily and traditionally also favored because of its environmental economic and ecological friendliness. Plant Metabolism materials serve as excellent reducing agents, which include phenolic compounds, alkaloids, and sterols.

Green Synthesis along with plant Mediation use the plants to extract, live plants which can also be used till date with more studies and have focused on the use of plant. The thrust behind the plant Mediated synthesis were attracting the major boost because of the fact that this route synthesis enables the product which can be exploited for multiple applications-based innovations.

Towards a Large-Scale Applicability: Micro-Organisms Nano Bio synthesis

The Micro-Organism Mediated Nano Sized Green Synthesis is possible by tuning the nano properties represent a concrete opportunity for future development and promising uses in bio sensoristics and biomedical fields. Despite all the advantages, microbial nanotechnology still has very limited uses; bacteria have showed the ability to synthesize nano structured materials either by extracellular or intercellular mechanisms which generally produce opposite advantages and disadvantages in terms of nano structured material who dispersity and purification. Extracellular produced nano structured materials are generally more polydispersed than intracellular produced nano structured material. By contrast, in extracellular nano structured material production less downstream extraction / purification steps are required. Thus, the extracellular Mediated synthesis endeavors the yeast and molds can greatly simplify the purification steps, besides being an advantage for a possible reuse of Micro-Organisms for Green synthesis cycle.

Characterization techniques

The Nano structured Micro-Organism characterization requires access to length scales range from that the constituent material to nano structured Micro Organism. In this connection, a complete structural analysis involves the implementation of complementary techniques, namely Scanning Electron Microscopy (SEM), Field Emission SEM, Small-Angle Scattering (SAS) Small-Angle X-ray Scattering (SAXS), Medium resolution Small-Angle Neutron Scattering (MSANS):

Scanning Electron Microscopy (SEM)

SEM scans over a surface with focussed electron beam and creates an image, which interacts the incident electrons in the beam with the sample produce a signal which obtain the information about the surface topography. A 2-Dimensional Scanning of the surface carried out by the electron probe and subsequent image acquisition from the detected secondary electron. Depend on the Topology of the Specimen; the number of secondary electrons can be detected. The Non-Conducting samples can also be characterized by a special type of SEM.

Principle

SEM technique requires electrons which are to be accelerated at a high voltage so that efficient probing of the sample is achieved through impingement. The accelerating voltage ranges from a few kV up to 30 kV. At such high voltages, the wavelength of the electron (λ), considering relativistic effects is given by,

$$\lambda = \frac{h}{\sqrt{2m_0 eE_0\left(1+ {eE_0}/{2m_0 c^2}\right)}}$$

Where h-Planck's Constant

E0-Applied Voltage

E-Electric charge (1.6 X 10-19C)

m0-Rest Mass (9.1 X 10 -31kg)

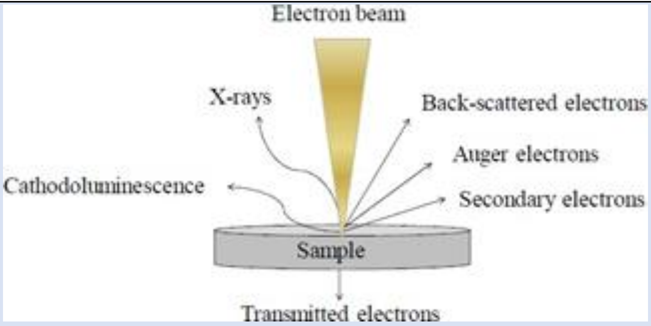

Figure 5: Emission of radiation and particles from the sample illuminated by the electron beam.

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Cite this article: Santhosh R. Kumar, Aravind R.P.S. (2023). Study of the Biodiversity of Fish in The Kufa River, *Pollution and Community Health Effects*, BioRes Scientia Publishers. 1(3):1-10. DOI: 10.59657/2993-5776.brs.23.011

Article History: **Received:** October 16, 2023 | **Accepted:** November 27, 2023 | **Published:** December 04, 2023