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The Primary Biological Aerosol Component in the Atmosphere- A Comprehensive Overview

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ABSTRACT:
Bacteria, dispersion units, fragments, and excretions of living creatures are only a few examples of the biological elements and structures that make up the extremely diverse collection of atmospheric aerosol particles. In a three-phase system, primary biological aerosol particles (PBAPs) are presented in this research in their most significant categories. PABAs have lately been found utilizing both contemporary and traditional techniques. Systemic or local infections are the main uses for aerosols. Different types of valves are used. Measuring valves and continuous spray valves continuously dispense the drug. The effectiveness of inhaled medications in the clinic depends on lung deposition, which is regulated by the aerosol properties. Create reliable and effective analytical methods for PBAP identification and quantification. Public health is affected by bioaerosols, which may also have a significant impact on climate.

I. INTRODUCTION

Primary biological aerosol particles (PBAPs) are identified as solid, airborne biological particles. [1] Due to their significant correlation with significant asthma and allergic rhinitis outbreaks, PBAPs released from the terrestrial biosphere, particularly pollen and fungus spores, have frequently attracted significant interest within the human health community.[2−5] Aerosol particle samples were collected using a technique designed specifically for atmospheric metabolic analysis.[6] Typically referred to as an aerosol [7–10], a suspension of liquid or solid particles in a gas with a particle size range of 109–104 m (lower limit: molecules and molecular clusters; upper limit: rapid sedimentation). Aerosol particle concentration, concealment, and size distribution in the atmosphere vary greatly over all of time and space. The complete count of In general, particle and mass concentrations in the lower atmosphere (troposphere) range between 102 and 105 cm3 and 1 and 100 mgm3, respectively[11–14].

There is a great deal of biological material, primarily anemophilous pollen, visible in the sky, especially during pollination seasons. The distribution of various plant species, wind, frost-free days, precipitation, and latitude all affect seasonal pollen emissions [15]. Many microscopy, spectroscopy, and mass spectrometry (MS) methods have been used to search for biological particles [16]. Because PBAPs may have negative effects on atmospheric processes and ecosystem function, identifying the source of PBAPs from aerosol mixes is particularly important because it increases the accuracy of climatic, environmental, and biogeochemical models. Finding the earliest PBAPs in the atmosphere is still difficult, though, because of the wide-ranging PBAP diversity and the spatial and temporal complexity. Secondary organic aerosols (SOAs), other organic aerosols, and PBAPs may all be observed. environmental samples of organic aerosol. may combine PBAPs, secondary organic aerosols (SOAs), and other organic substances generated from anthropogenic sources[17,18,19].

The effects of biological aerosol particles on the carbon, nitrogen, sulfur, and phosphorus cycles, cloud and precipitation processes, atmospheric chemistry, and possible global climate change contributors are all interconnected. They can act more readily and effectively as ice nuclei or cloud condensation (CCN), for example, when compared to the majority of other forms of aerosol particles. Large biological particles, such some pollen grains and fungal spores, can cause precipitation to begin [20,21]. The primary disease-

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carrying agents for people, animals, and plants are airborne bioparticles [22]. There is no recognized mechanism for the claim that pollen and spores specifically aggravate asthma, allergies, and other respiratory conditions during thundershowers [23–27].

Forests are a major source of primary biological aerosols in the atmosphere[28–31]. Large woodlands have high levels of biological particles from nearby plant emissions and low levels of anthropogenic pollutants from long-distance transport[32–35]. In ecosystems with various anemophilous pollination seasons (i.e., temperate and boreal locales), pollen concentrations have been found to range between 0.04 and 0.8 g m3, with a peak concentration of pollen submicron particles (subpollen particles) during rainy events [36]. Submicron particles may also affect the Earth's overall radiation budget due to the fact that they scatter and absorb sunlight. Subpollen particles may be to account for a decline in precipitation events under clean continental environmental conditions, despite the fact that their air number is unknown.conditions and They have an adverse feedback effect on the formation of subpollen particles, which affects the mass loading of all organic aerosols in the atmosphere [37].

Laboratory research has shown that certain bacterial species, fungal spores, and pollen are more effective IN [38-42]. Bioparticles have been found in clouds, fog, rain, snowfall, and other weather conditions. Bioaerosols can affect the human respiratory system, and this is particularly well documented [43–46]. In several investigations over the last few decades, scanning electron microscopy (SEM) has been used to define the size and morphology of individual PBAPs [47–52]. They discovered fungus spores, brochosomes, pollen, and plant or insect waste greater than 2 meters in the sky. Even while the coarse fungal spores, pollen, and plant or insect waste particles were adequately described by the SEM observations, comparable results for the tiny bacteria and fungal particles, which together account for a sizable percentage have not been met for suspended particles. Through electronic tools in open air [53–59].

TYPES OF AEROSOL SYSTEM:

Water-based system:

The water-based system consists of a vapor phase, a propellant phase, and a three-phase system. The ingredients are typically dissolved by adding a lot of water. It is advised to add cosolvents like ethanol and surfactants in the range of 0.5% to 2.00% because the propellant employed is typically immiscible with water [60]. These surfactants reduce the interfacial tension that forms between the water and the propellant. The propellants of choice for these systems are often hydrofluorocarbons (HFC), hydrocarbon (HC) blends, pure HCs, nitrogen, and dimethyl ether. One issue with these systems is that the carbonic acid produced by the additional propellants, which can change the pH, causes container corrosion. coming from the carbonic acid that the additional propellants produce, which might change the product's pH and hence its stability. Additionally, one of the primary drawbacks of water-based aerosols is the inclusion of ethanol, which has been shown to increase the product's flammability. Because of this, corrosion inhibitors are typically incorporated into the formulation, and water-based solutions are typically packaged in phenolic, urethane, or epoxy-lined containers [61].

1. Solution system

To spray the formulation, a homogenous mixture of the product concentrate and propellant is required. Utilizing solvents like alcohol, glycols, and acetone are specific formulation approaches [62]. The majority of propellants or mixes of propellant solvents lack polarity [61] Therefore, one common constraint is the inability to dissolve all of the constituents in the product concentration, including the extensively used HC propellants [62]. Once the propellant and product concentration are mixed, the two-phase system will be created[61]. The concentration of the propellant, the vapor pressure, the solvent being utilized, and the valve features have all been seen to have an impact on the spraying rate in various tests. Even so, the pressure needs to be high enough to allow the formulation to be expelled at a reasonable rate. the ideal circumstances for operation. The size of the droplets as well as the spray's wetness and dryness are also discovered to be influenced by the propellant concentration [62].

2. Foam/emulsion system

The process in which the product concentrate and propellant are emulsified is frequently referred to as a three-phase system. The emulsion will be released upon valve actuation, and when the propellant evaporates, bubbles will form inside the formulation. Typically, the product is expelled by the o/w emulsion system as foam. To

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 5 Sep-Oct 2023, pp: 973-985www.ijprajournal.com ISSN: 2249-7781

create the appropriate foam, tiny amounts of HC propellants can be used, such as 3%–4% in 90%–97% emulsion concentrate [62]. When the propellant is used, the product concentrate will quickly evaporate and be released as foam. Fig. 3.1 shows how the formulation enters the environment (Allen and Ansel, 2014)

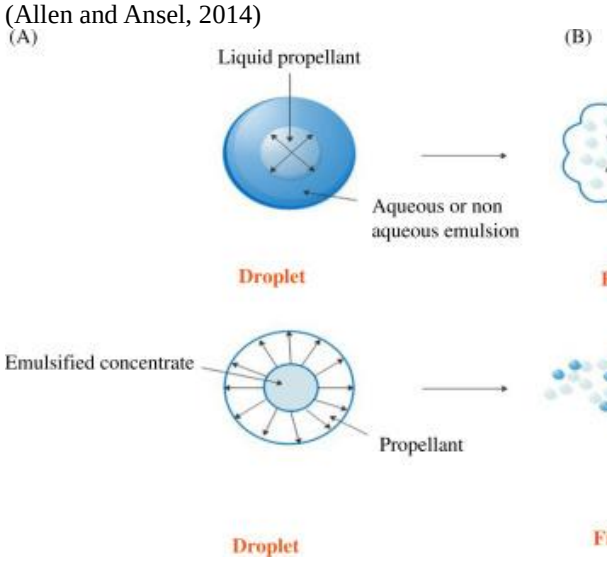

Fig: Propellant-containing aerosol emulsion droplets (A) in the internal phase, which leads to the development of aerosol foam, and (B) in the exterior phase, which leads to the formation of aerosol foam.

3. Suspension or dispersion system

In these types of systems, the components must be introduced in solid form, such as in the form of a powder aerosol, and suspending agents are typically added to help with the susceptibility or dispersibility of the solid particles inside the propellants. Moisture, particle agglomeration, sedimentation, and compaction are further factors that must be taken into account. While the other factors stated are often limited to prevent tiny particles from clogging the valve, the moisture content is typically adjusted below 300 ppm [62]. Typically, this kind of aerosol system is used when the product concentration is largely insoluble in the propellant. The extra propellants in this system can, however, be a single propellant or a combination of several propellants. Illustrations of suspension aerosol Antibiotics, steroids, and antiasthmatic medications are examples of products. When the valve in this system is opened, the suspension will be ejected from the aerosol and the propellant will quickly vaporize, leaving a fine dispersion of the product concentration [61].

Techniques for PBAP collection and analysis:

3.1 PBAP sampling methods:

Knowledge of the basic concepts governing interactions with suspended particles (B100 mm) is essential for the sampling and collection of atmospheric aerosols [63]. To avoid significant biases in quantitative and qualitative knowledge, sampling techniques must be carefully planned [64]. Losses of particles within inlets, inlet lines, and equipment can lead to substantial biases in both. The losses resulting from gravitational settling and inertial surface impaction have a greater impact on large particles (>5 mm) than they do on small particles (B0.1 mm), which are more vulnerable to Brownian diffusion and electrostatic forces. Furthermore, air turbulence can cause particles of all sizes to lose their momentum and fall to surfaces. Other sources [65,66] cover these topics in greater detail. Contrary to conventional aerosol sampling, however, biological aerosol sampling frequently necessitates unique handling techniques.of inert particles, which are here briefly introduced. Although problems with sampling because of particle size impacts are not specific to biological aerosol sampling, PBAP size and mass are frequently difficult to estimate because of complex interactions between the biological tissue and ambient factors like temperature and relative humidity[67,68].

3.2. Traditional analysis methods:

The variety, identity, and concentration of airborne microorganisms were predominantly investigated using microscopic examination and cultivation methods on both selected and non-selective medium before the development of molecular and other physicochemical approaches. These techniques have a long and rich history in aerobiological research and are still effective instruments for PBAP investigation. The categories used here ('traditional' and'modern') are therefore historical and somewhat arbitrary, but useful for a broad categorization. This text's limitations prevent a comprehensive treatment of these techniques, but it can be found elsewhere (e.g. Cox and Wathes, 1995).[69]

3.2.1. Light microscopy:

Microscopic techniques have been crucial to the history and advancement of PBAP analysis in addition to cultivation, and they continue to be priceless instruments. Numerous methods of light microscopy have been used to characterize collected PBAP (Spurny, 1994; Cox and Wathes, 1995 and references therein)[69,70]. It continues to

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be the most popular analysis technique for pollen. The earliest method used for PBAP analysis was straightforward optical microscopy in the seventeenth century [71]. and has been widely used ever since. However, it must be remembered that particles B2 mm can only be seen as dots under an optical microscope and cannot, thus, be thoroughly analyzed in terms of their size and shape. Aerosol samples obtained using impaction and sedimentation equipment can be Light microscopy allows for immediate visualization and counting. The quantity of airborne particles can be measured if a volumetric sampling instrument is utilized. However, since the particles must be counted by eye, direct counting is a very laborious and sometimes arbitrary method of identifying biological particles. Light microscopy can be used in conjunction with a number of conventional stains, such as methylene blue for straightforward examination and Gram staining and other differential staining methods to help classify specimens into groups of species. An estimation of all (total) PBAP is provided by protein staining [71].

3.2.3. Fluorescence microscopy:

Fluorescence microscopy has been used to examine PBAP's autofluorescence [73] and more specifically, the labeling of fluorescent dyes [74,75]. Direct fluorescence microscopy is the most widely used conventional technique for calculating the total number of environmental microorganisms. This technique either makes use of the autofluorescence of specific biological compounds or utilizes samples that have been treated with a fluorescent dye, most frequently 4.6-diamidino-2-phenylindole (DAPI) or acridine orange [76–80]. Although the color of Some large groupings of bacteria can be distinguished using autofluorescence in conjunction with fluorescent stains. Despite the fact that fluorescence microscopy is more labor- and time-intensive than light microscopy, it is more effective in identifying biological particles. Fluorescence spectroscopy [82,83] and computer analysis of microscopic images [81] are recent examples of more automatic techniques that have been tried

3.3. Modern analysis methods:

3.3.1.Breakdown spectroscopy:

Although they haven't been as commonly used for ambient measurements, many groups have also used various kinds of breakdown spectroscopy (BS) to determine elemental composition as a technique of biological aerosol detection and analysis. The method of laser-induced breakdown spectroscopy (LIBS), which has been used to characterize pollen (84), fungal spores (85), bacteria (86), and various biological aerosol particle types (87), is unquestionably the most popular type of BS approach. The study of biological aerosol in a laboratory setting has also made use of other types of elemental analysis, including spark-induced breakdown spectroscopy (SIBS), particle-induced X-ray emission (PIXE), and various types of combustion analysis [88,89].

3.3.2. Miscellaneous non-optical-methods:

A wide range of non-optical techniques for chemical and physical analysis have been used, much as has been the case with recently discovered optical methods of biological aerosol study. The potential analytical advantages of bioluminescence and chemiluminescence have been thoroughly investigated, with much of this work concentrating on the detection of ATP inside collected aerosol [90, 91,92]. For PBAP characterization in the ambient environment, electrochemical, immunochemical and immune biological approaches have also been examined [93-96]. It should be mentioned that auxiliary instruments, like biological aerosol particle concentrators, have also made it possible for many devices to conduct analyses.[97]

Advantages of aerosol:

• It's simple to use pharmaceutical aerosols.
• Aerosol administration provides very immediate and effective relief.
• Since the medicine is not exposed to ambient oxygen and moisture while stored in MDIs and DPIs, its stability
is increased.
• The affected areas can receive a direct application of the medicine.
•Aerosol drug administration is a quick process.
• It guards the medication against gastrointestinal tract deterioration.
• First pass metabolism in the liver can be prevented.
• Both systemic and local applications are possible for aerosols.
• A sterile dose of the medication is administered, and drug contamination is also avoided.[98]

Disadvantages of aerosol :

• The dosage form is expensive.
• A challenge in getting rid of empty containers

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• It could result in an explosion; in certain situations, allergic reactions;
• It can be difficult to produce insoluble medication dosage forms in aerosol form.
• Harmful reactions can occasionally be caused by propellants.
• Because there are trace metals in the container, it occasionally contaminates medications.[98]

How does aerosol work :

Figure displays the different parts of an aerosole. Depending on the type of medication, a container may be constructed of metal such as aluminum, tin-plated alloys, glass, or plastic. The container's size is also determined by the number of doses and other requirements. The container's main use is to keep or store the aerosoles. Typically, it is completely and securely sealed. both drugs and propellants cannot escape.

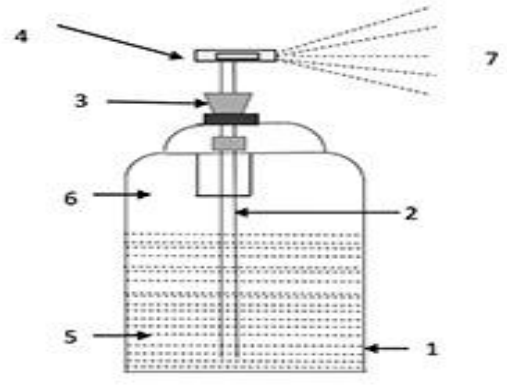
The container's lowest point allows for the insertion of a deep pipe. At the top, where the deep pipe is attached, an appropriate valve is fastened. the valve's delivery of the contents function. Various valve types are employed. Continuous spray valves spray the medication constantly, while metering valves, when opened, spray a measured amount of medication via the exit tube on the side of the valve, which is often kept securely closed.

The valve is firmly held in place by a spring. The valve is controlled by a push-button actuator, which is often left in the "up" position. The actuator's job is to open the valve and cause the appropriate types of discharge. The medicine, whether liquid or solid powder, is kept under tension or in a propellant solution, whose vapor fills the empty space in the container and exerts pressure inside it. The propellant's job is to build pressure inside the container and force the product out. Propellers come in a variety of forms. Most frequently, tri-chloro-fluoro-methane and di-chloro-di-fluoro-methane are used.

In order to open the valve, the actuator button must be depressed all the way to the bottom. The top of the valve has an orifice where the pressurized medication and propellant can exit as an aerosol or mist jet. The spring again extends and closes the valve when the actuator button is released.

For systemic drug administration as well as local treatment of pulmonary diseases like asthma and chronic obstructive pulmonary disorder (COPD), drug delivery to the lungs is an appealing method. The creation of dry powder aerosols, which don't need a propellant, have better chemical stability than solutions, and are simple for patients to use, has received a lot of attention. Dry powder inhalers come in two flavors: passive, or breath-actuated, and active. The patient's exertion during inspiration provides the dispersion energy for passive devices. Active devices, on the other hand, reduce the amount of effort required to inhale by fluidizing the powder using a separate mechanism (a motor or pressurized gas). The third generation of active devices has also been used in the literature DPI.

The lung deposition of inhaled medicines, which is influenced by the aerosol characteristics, determines their clinical efficacy. For DPIs, the aerosol qualities are determined by the powder's dispersion, which is complicatedly influenced by the patient's inspiratory flow rate, the device, and the formulation. In vivo lung deposition studies can be used to investigate the impact of various factors on lung deposition.[98]



1-container, 2 –deep pipe, 3- valve, 4-actuator, 5-drug and liquid propellant, 6 – propellant vapor, 7 – spray jet

Figure 1 Components of aerosols

Fig: parts of aerosol

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 5 Sep-Oct 2023, pp: 973-985www.ijprajournal.com ISSN: 2249-7781

Aerosol patent:

List of products with patents set to expire between January 2013 and August 2021

Drugs	Generic	Patentexpiration	Sales in 2012 (millions)
Evista®	Raloxifene	2013 1Q(Jan)	$534
Zomig®	Zolmitriptan	2013 2Q(May)	Tablet:$165 ZMT:$34 Nasal:$25
Fosamax Plus D™	Alendronate /cholecalciferol	2013 2Q(Jun)	$240
Eloxatin®	Oxaliplatin injection	2013 4Q(Oct)	$6
Aciphex®(tablets approved but not launched 2/07)	Rabeprazole	2013 4Q(Nov)	$1,159
Fuzeon®	Enfuvirtide injection	2013 4Q(Dec)	$43
Cymbalta®	Duloxetine	2013 4Q(Dec)	$2,294
Asacol®	Mesalaminedelayed release tablet	2014 1Q(Feb)	$494
Avodart®	Dutasteride	2014 1Q(Mar)	$389
Advicor®	Lovastatin/niacin	2014 1Q(Apr)	$106
Viracept®	Nelfinavir	2014 2Q(Apr)	$71
Namenda®	Memantine	2014 2Q(May)	$606
Nexium®	Esomeprazole	2014 2Q(May)	$5,080
Celebrex®	Celecoxib	2014 2Q(Jun)	$1,634
Actonel®6	Risedronate	2014 2Q(Jul)	35mg:$765 5mg:$1275mg:$28
Micardis®	Micardis®HCTtelmisartantelmisartan hydrochloride	2014 3Q(Aug)	$163
Temodar®	Temozolamide	2014 3Q(Aug)	#224
Maxalt®	Rizatripan	2014 3Q(Aug)	$235 (does not MLT form)
Exelon®7	Rivastigmine	2014 3Q(Sep)	$203
Avelox®	Moxifloxacin	2014 3Q(Nov)	$514
Copaxone®	Glatiramer	2014 4Q(Jan)	Injection $391
Cipro®HC	Ciprofloxacin/hydrocortisone otic suspension	2015 1Q(Feb)	$46
Lumigan®	Bimatoprost ophthalmic solution	2015 1Q(Mar)	$253
Sustiva®	Efavirenz	2015 1Q(Mar)	$192
Renagel®	Sevelamer	2015 1Q(Mar)	$394
Welchol®	Colesevelam	2015 2Q(Jun)	$221
Travatan®	Travoprost ophthalmic solution	2015 2Q((Jun)	$120
Patanol®	Olopatadine solution	2015 4Q(Dec)	$256
Relpax®	Eletriptan	2017 2Q(May)	$231
Byeetta®	Exenatide injection	2017 3Q(Jul)	$627
Zetia®	Ezetimibe	2017 4Q(Oct)	$1,232
Vytorin®	Ezetimibe/Simvastatin	2017 4Q(Oct)	$1,635
Spiriva®	Tiotropium powder for inhalation	2018 3Q(Jul)	$1,191
Nasonex®	Mometasone nasal	2018 4Q(Oct)	$1,045

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 5 Sep-Oct 2023, pp: 973-985www.ijprajournal.com ISSN: 2249-7781

	spray		
Lyrica®	Pregabalin	2019 3Q(Jul)	$1,492
Detrol®LA	Tolerodine	2020 2Q(May)	$729
Crixivan®	Indinavir	2021 3Q(Aug)	$12

Characteristics Of Aerosols:

- The propellant's pressure causes the contents to be released. If the contents are a solubilized system with 40–70% liquefied gas, they are discharged as a mist; nevertheless, if the contents are an emulsion system with 5–15% liquefied gas, they are discharged as a foam.
- The extension tube, which is attached to the actuator, facilitates product flow and aids in getting into tight crevices.
- The container's bottom is not flat, which aids in regulating the buildup of pressure inside the canister.
- Aligning the dip tube with the valve plate's color indication will allow the liquid within the container to be entirely emptied.[99]

Type of aerosol formulation :

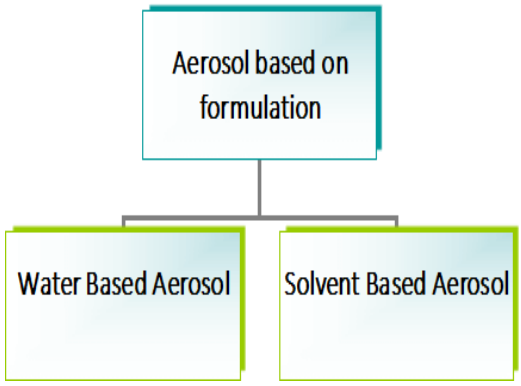


Fig: types of aerosol formulation

Water-Based (Emulsions, Dispersions):

Normal packaging for water-based products includes lined and double lined cans with phenolic resin, urethane, or epoxy linings.If an efficient corrosion inhibitor is applied, they can also be kept in unlined cans. Hydrocarbons, hydrocarbon blends, dimethyl ether, hydrofluorocarbons, and nitrogen are the typical propellants utilized in aqueous products. Only carbon dioxide is often not employed as a propellant in watery formulations. In an aqueous solution, this propellant will produce carbonic acid, which may lead to corrosion issues and may also have an impact on the physical characteristics of the final aerosol product.Most water-based aerosols are probably discharged using a hydrocarbon propellant at a 4–10% level due to expense.

Solvent Based (Water in Oil, Dispersions):

Most solvents will remove the internal coating of the can, hence unlined containers are typically utilized.A corrosion inhibitor will probably be required if the concentrate has more moisture than 0.1% in it. In some circumstances, interior can corrosion could occur even with moisture contents of less than 0.1%.Hydrocarbons, hydrocarbon blends, and hydrofluorocarbons are the three types of propellants utilized in solvent formulae.Normal requirements for the liquified gas propellant in solvent formulas are higher. To completely discharge the container, propellant concentrations as high as 1/3 of the product's Net Content may be required. In these formulae, the DME, Hydrofluorocarbon, and Hydrocarbon propellants typically serve as solvents. Carbon Dioxide concentrations in solvent formulations range from 2 to 7%, while nitrogen will range between 0.5 and 2%.In the concentrate, carbon dioxide saturation is higher than nitrogen saturation.[99]

II. CONCLUSION :

PABAs are biologically derived solid airborne particles that are released from fungi and other organisms in the biosphere. To collect aerosol particle samples, atmospheric metabolic analysis was used. Total particle count and mass concentration in the troposphere are 102 and 105 cm3 respectively. In ambient organic samples, secondary aerosol may all be visible. Climate is the principal source of PABAs in the atmosphere. Clouds, fog, and snowfall all contain aerosol particles. The respiratory system of humans may be harmed by bioaerosol. Over the past few decades, SEM has conducted a lot of studies to define the size and shape. In an aerosol, four main systems are at work.systems that are water-based, solution-based, foam emulsion-based, suspension- or dispersion-based. Propellers are primarily employed in all of these systems, because it aids in maintaining steady or nearly constant pressure, produces a consistent spray of the product in the form of an aerosol, and has the dual purpose of giving another substance or object motion. PABAs

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 5 Sep-Oct 2023, pp: 973-985www.ijprajournal.com ISSN: 2249-7781

are collected and analyzed using both contemporary and conventional methods in significant amounts.

Future perspectives:

Small airborne particles known as aerosols are produced by both natural and man-made sources. By interacting both directly and indirectly with solar and thermal radiation, clouds, and atmospheric circulation, they have an impact on the climate.Aerosol could be significant for overall health and could contribute significantly to the problem of abundance.The aforementioned analysis of the connection between aerosol and precipitation makes it evident that studies relating aerosol to clouds have only been conducted over India. These observations and analyses will quantify the mixing of aerosol, aerosol type, the role that absorbing and scattering aerosol play in aerosol-cloud-precipitation interactions, and their impact on summer and monsoon rainfall across India. As a result of these research' findings, we will have a better and more trustworthy understanding of the temporal distribution of aerosol and cloud characteristics.measurement of aerosols' direct and indirect radiative effects.

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