ISSN:0971-1260
Vol-22-Issue-10-November-2019

Implications Of Aerosol Constituents For Changing The Climate Pattern

***Jacob Joshua and Sujatha C H**

Department of Chemical Oceanography,
School of Marine Sciences, Cochin University of Science and Technology, Kerala, India

Abstract

Aerosol Chemistry is of great concern over the current period owing to their manifold contribution in various scientific disciplines akin to biogeochemistry, physics, earth sciences, meteorology, public health etc. Though the airborne aerosol particle ranges from nanometer to micrometer size, they are active in the participation of hydrological cycles, the circulation pattern of the atmosphere, the energy balance of the Earth, variation and distribution pattern of the reactive trace gases including Green House Gases (GHGs), production of atmospheric cooling volatile gas, the Dimethyl Sulphide (DMS) and thereon. Eventually ends to the spreading of various diseases causing pathogens and affecting the public health and also make control over changing the climate sketch. Due to the spatio-temporal difference and variations in geographical pattern throughout the globe, the analytical techniques in network monitoring and quantifying for Air Quality (AQ) has become a tedious and inefficient approach. Therefore, new sophisticated techniques and technologies are developed in the new scientific era for Air Quality (AQ) monitoring, estimating and finally their effective assessment in each country. Hence, worldwide both ground and satellite monitoring approach have come up in a more systematic manner. This review articles attempts to represent a brief outline on the characteristic properties of the aerosol constituents, their varying sizes, health impacts and monitoring strategies.

Key words: Aerosol Chemistry, Air Quality (AQ) monitoring, Green House Gases (GHGs), Public health.

Introduction

Worldwide, the scientific community has agreed and concluded that anthropogenic activities are altering the Earth's climate pattern by changing the overall infrared radiation flux in the troposphere and will continue in an upheaval level in the coming years. The input of atmospheric trace gases including Green House Gases (GHGs) such as carbon dioxide(CO_2), methane (CH_4), nitrous oxide (N_2O) etc. formed by means of natural ways and human activities (IPCC, 2007) and results a continuous rise in the Earth's average temperature. Both at national and regional levels, Climate Change (CC) is having disproportionate adverse effects specifically on minorities, old people and children etc (Pandey et al 2002, Barnett et al 2005, Kaushik et al 2006, Gayathree et al 2016). CC has developed a pathetic situation to poverty reduction. To ensure sustainable development, active participation is in the processing way of these years. Age

ISSN:0971-1260
Vol-22-Issue-10-November-2019

old definition of climate makes us to understand that it is the weather conditions prevailing in an area over a long period of time. Recent estimates also suggest that at current emission rates, the earth could pass a threshold of 2ºC global warming, in which the United Nation's Intergovernmental Panel on Climate Change, IPCC (Sunderesan 2011, Boucher et al, 2013, Fuzzi et al., 2015) designated as the upper limit to avoid "dangerous" global warming, by 2036.

In association with the atmospheric temperatures, both physical and biological impacts are coupled and are being noticed day by day in the whole ecosystem. Among them, owing to the dynamic and physically diversified nature, coastal zones have become the most conducive attractive economic environment throughout the world. These highly productive and assorted characters supply a broad spectrum of basic amenities of changeable lively hoods for mankind (Nair et al 2006, Nair et al 2008 Sunderesan 2011, Gayathree 2016). Enough number of environmental consequences such as in the profile of sea level rise, increased surface temperatures which has in turn shaped a variation in precipitation, intensity in rain fall to lead land erosion, storms, flood and drought etc (Mukhopadhyay and Kreycik 2008). The dramatic alteration increases the frequency in magnitude of the weather events geographically, resulting a drastic change in the life of the coastal inhabitants. The drought and flood situation convert the cultivable land in to a barren land along with land mass loss, consequently famines will come up in their livelihoods. This alteration are superimposed on the existing distorted poor communities and affect their health, accessibility to drinking and aesthetic water and end with a calamity and warning in the food insecurity. Furthermore, the advent of new technologies and human related activities has made a cataclysm for creating a haphazard grave concern on climate change. The marked transformations over the natural resource commodities ultimately altered the economic wealth of the whole Nation.

Figure 1.Pollution Catastrophe in NCR, Delhi and Kochi

Source (https://www.patrika.com/becomes-highest-polluted-city-of-ncr-3642307/)

There is no particular kind of weather pattern or climatic conditions in an area now, and day by day the situation is severe (Figure.1.). Since the ecosystem as a whole is very much disturbed, even if one wants to improve the condition by a small extent, a great deal of work and material sacrifices are required. Previously IPCC (IPCC2007), have reported that developing countries in subtropics and tropics are expected to suffer greatly of these weakness due to their close connection and enslavement on agriculture and fishery sectors. Parallel to these, their poor

ISSN:0971-1260
Vol-22-Issue-10-November-2019

response towards anticipating climate change and limited financial constrains also favor the circumstances. CC are causing additional economic burden and develops a very emotional threat to the society. Hence adaptive mechanisms will be strongly recommended and implemented by various ways such as procuring natural resources and their proper management, institutional governance practice, and better exercise of the human empowerment etc. Many International organizations (UNESCO/WHO/FAO etc) have come forward and are being actively involved towards the protection of the environment, thereby sustaining the environment for the future generations. The United States Environmental Protection Agency (EPA) began to impose regulations of carbon emissions from traffic vehicles and power plants from years long and all the efforts are in vain. Many smaller organizations involved massively, towards a sustainable environment for the future. The topic of discussion is limited towards the climatic changes of the world look today due to the umpty number of destructions facing the ecosystem's segments.

Atmospheric Aerosols (AAs)

The mounting evidence proven that the atmospheric aerosol (AA) distribution and their constituent is having a strong influence on the radiative forcing character for climate by reflecting sunlight back to space (Kiehl 1999;Penner et al, 2001;) and its effect on cloud microphysics and albedo (Twomey 1977).The aerosol showing a reverse trend in magnitude of the green housegases (GHGs)
and observed a different spatial distribution and diurnal cycle, causing a complex climatic impact.

Aerosol, the most dominant constituent of the earth-atmosphere system are formed mainly from various indigenous man-made sources like industries, vehicular / traffic emissions and other natural sources as wind-blown dust from desert, forest fire which results smoke and fog, bursting of bubbles forming sea salt on ocean surface, occurrence of biomass burning in the tropical rain forests etc. Other than the sea salt, the marine aerosol, one of the major constituent of primary natural aerosol includes mineral dust, biological aerosols and volcanic ash. It is a complex constituent including both primary and secondary pollutants (Rengarajan et al 2007, Rastogi and Sarin 2009, Arnold 2008, Stasangi 20013, Fuzzi et al. 2015). The primary pollutants are generated through biomass burning, traffic and industrial emissions, the photochemical reactive moieties of biogenic organic volatiles etc (N. Manojkumar and B. Srimuruganandam, 2019). Of the secondary organic and inorganic particulates, the Organic Aerosols (OA) are derived from biomass burning, contributing a profound effect on regional air quality and visibility, ecological systems, human health, global radiation balance and climate (Fuzzi et al. 2015). Mineral dust particles as the dominant atmospheric aerosol component contains iron, phosphrous and other productivity inducing micronutrients and ultimately modifies the atmospheric ocean cycles (Eleftheriadis and Colbeck 2001. Jickells, et al 2005). Through the direct and indirect effects, it alter the marine biogeochemistry and rework in the climate profile.

Size, Distribution and Composition of Atmospheric Aerosols (AAs)

ISSN:0971-1260
Vol-22-Issue-10-November-2019

The concentration, size, distribution and composition of AA particles are spatio-temporarily highly distinctive and variable. According to the properties of different types of atmospheric model aerosols, their characteristics are expressed in terms of fine and coarse fractions. These freshly formed fine fraction constitute very small particles (diameter <0.01 µm) and also called the "ultrafine". The coarse particles or the "giant" one are generally larger than about 1 micron or having an aerodynamic diameter of 2.5 µm. Generally several key AAs exists and are originated from urban, marine, rural, remote continental, free atmosphere, polar and desert. The marine aerosol particle concentration (100-400 cm^{-3}) PM_{10} (10µgm^{-3}) belong to the lowest classification and are in the "pure" state. Urban aerosols (UAs) are the "polluted" one with the highest number (10-4x10^6 cm^{-3}) PM_{10} (100-300 ugm^{-3}) concentration. Rural AAs are having a number concentration as 2000-10,000 cm^{-1}; PM $_{10}$ (10-40 µgm^{-3}) and the Remote continental AAs have the lowest mass concentration (50-10,000) PM_{10} (2-10 µgm^{-3}). These fine and coarse particles are having different composition (Seinfeld and Pandis, 1998). The formation pathway of fine particles is due to the process of chemical reactions, nucleation condensation, coagulation, cloud/fog formation. They constitutes sulphate , nitrate, ammonium, hydrogen ion, elemental carbon, organic compounds, metals (Pb, Cd, V, Ni, Cu, Zn, Mn, Fe etc) and are largely soluble, hygroscopic (Subhasish Ghosh et al 2013). Their sources are combustion (coal, oil, gasoline, diesel, wood) gas to particle conversion of NO_x , SO_3 and VOCs, smelters, mills etc., and their life span is days to weeks and travel to a distance of 100 to 1000 kms. (Bhanarkar et al 2005). On the other hand, coarse particle's derived pathways are mechanical disrupt, suspension of dust. Their composition is re-suspended dust, coal and oil fly ash, crustal element (Si, Al, Ti, Fe,) and their oxides, $CaCO_3$, NaCl, sea salt, pollen, mold, spores, plant, animal debris, and tire wear debris etc. They are largely insoluble and non hygroscopic. Their sources are re-suspension of industrial dust and soil, suspension of soil (farming, mining, unpaved roads), biological sources, construction/demolition, and ocean spray. The life time of AAs fit into minutes - days and travel to a distance of <10s of Km.

Interrelation between Aerosol and climate

Subdividing the causes of climate change, the reasons mainly represent physical and chemical factors. The foremost physical factors are temperature, cloud condensation nuclei, rain fall intensity, natural hazards etc. These physical factors other than temperature differences, changes are being occurred in the rainfall patterns and natural hazards similar to earthquakes, tsunami and floods which are equally bring in destructions of the ecosystem. The cloud condensation nuclei (CCNs) also known as "cloud seeds" are small particle of the range 0.2µm, or 1/100^{th} the size of a cloud droplet on which water vapor condenses (Saleeby et al 2009). As water vapour is an effective green house gas, this is also an important reason for changing or regulating climate. The atmospheric trace gases together with the Green House Gases (GHGs), the anthropogenic derived constituents like volatile organics, black carbon along with the important cooling gases include in the chemical classification. Nitrogen, Oxygen, argon, carbon dioxide, also trace amounts of neon, helium, methane, krypton, hydrogen and water vapour constitute the earth's atmosphere. Any of these gases exceeding its permissible limits amounts to contribute towards

ISSN:0971-1260
Vol-22-Issue-10-November-2019

air pollution and thereby cause climate changes. The changes in percentage of these gases are mainly due to vehicular and industrial emissions of gases and also certain natural factors like volcanic eruptions. The green house gases water vapour, carbon dioxide, methane, nitrous oxide, and ozone are present in the atmosphere and they absorb and emit radiant energy within the thermal infrared range, which is the fundamental cause of green house effect. The human activities since the beginning of industrial revolution has contributed in a very high increase of the green house gas especially carbon dioxide. It has been estimated that if green house gas emissions continue at their present rate, very soon within a few years, it will have every capacity for potentially harming the ecosystem, biodiversity, and also the livelihood of the people worldwide. Aerosol particles are showing a profound impact on several biogeochemical processes by allocating a room for speedy chemical reactions. Mineral dust particles originated from arid and semiarid regions in conjunction with biomass burning are making a fundamental role by serving as the liquid phase that stimulates chemical reactions and develops a chemical changing pattern of the troposphere (Sokolik et al 2008).

Climate Forcers

Anthropogenic Aerosol Forcers

The vast and wide majority of anthropogenic gases like carbon monoxide, sulphur dioxide, carbon dioxide all that emerge from a single source human activities like combustion of fossil fuels like coal, oil, or natural gases, and from thermal power plants, industrial activities, environmental destruction like deforestation, changes in land use, soil erosion, and agriculture practices using a wide range of harmful chemicals and pesticides. Along with the anthropogenic sources of aerosol constituting industrial or urban including biomass burning, the dust originated from land reclamation changes also regarded in the list of man-induced atmospheric aerosol (Subhasish Ghosh et al 2014).

Altogether these dealings will in turn become a part and parcel of the atmospheric chemistry. The evolved anthropogenic gases have a very awful impact towards the environment and also contribute in large number of deadly diseases. SO_2 is one of the priority gaseous air pollutants that have generated from various human made activities such as wood burning, vehicular transport , industrial units and power plants. The largest sources of sulphur dioxide emission are from fossil fuel combustion at power plants and other chemical industries. Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulphur containing fuels by locomotives, large ships, and non-road equipment(He et al 2017, Lu et al 2017). Anthropogenic pollutants specific to each geographical area are also experience the incidence of monsoon effects drastically where it initiates the pollutants to transport from one region to another. These trace gases is the main causative agent for the outbreak of acid rain and replenish and deteriorate the precious historic architectural monuments.

Aerosols and clouds

ISSN:0971-1260
Vol-22-Issue-10-November-2019

Aerosols scatter light and thereby change the reflectivity of the Earth. The widespread distribution of aerosol particles in the earth's atmosphere subsequently form the cloud condensation nuclei (CCN) which facilitates to develop clouds to decide the rain shower intensity profile. The CCN serve as the tiny seeds to form clouds and these processes alter the climate pattern. The major source of CCN in the marine environment is dimethyl sulphide (DMS). These are mainly evolved from phytoplankton (Charlson et al 1987) showing a cooling effect to the atmosphere and are merely below 50% than that of the GHGS's warming effect. Clouds, the strong modulator of the shortwave and long wave components of the earth's radiation budget (Ramanathan 1987; Ramanathan et al. 1989) and climate regulator. The spatiotemporal variations of cloud properties signify the impact of greenhouse gas effects on climate regulation. Further it modifies the cloud cover in the atmosphere and will enhance the number of polluted clouds leading to global warming (Small et al 2009). This climate induced changes in the content of liquid water and in turn cloud optical thickness account their change in positional structure. These greatly neither influence either as a negative result nor when comparable in size showing a positive effects. The indirect effect of aerosol is a global phenomena making an opposite effect of GHGS and guide for atmospheric cooling. Generally aerosol effect is region specific, while GHGS have consistent global impact owing to the widespread spatiotemporal variations which can be noticed in these indirect processes. Aerosols suppress precipitation by means of decreasing the size of water droplets to produce clouds and turn into a smoky atmosphere and warms the surroundings (Denman et.al 2007; Forster 2007). However, certain environmental conditions also favor for a grounds to pour heavy rainfall and lightning. Some of the reflective aerosols are ready to brighten the clouds much greater and increase the life span (Small et al 2009). The aerosol and cloud properties such as the optical, microphysical properties along with the total precipitable water vapor and the atmospheric stability provides a clearway of understanding the earth-atmosphere-Ocean system(Kim et al 2015). All these could transfer the information about the dynamic properties of the atmosphere.

The chemical reaction involved in the biogenic emitted volatile sulphur compound is initially oxidized to sulphur dioxide and other bye products. Later the non-sea-salt (nss) sulphate produced from the SO_2, is yet again converted to the sulphate (SO_4^{2-}) particles for acting as a condensation nuclei for water vapor. This could alter the radiative properties of the atmosphere and clouds. This will deflect back the incoming solar radiation from the earth to space and thereby regulate and have a control over reducing Earth's temperature. The anthropogenic derived SO_2 from industrialized areas indicates counteracting effects than biogenic sulphur dioxide and have a strong influence on greenhouse effect for raising the atmospheric temperature. Other than the natural source for cloud formation, the human activity related fine particulate matter (fpm) mainly get from fossil fuel burning, industrial activities, ship and aircraft track emissions greatly modify on cloud albedo formation to lower the strength of sunlight rays and generate CO_2 and creates a warming atmosphere (Pope et al 2009). The ability of this fpm to travel across country without hindering the geographic boundaries formulating "a watch word and a scare crow" making it as a matter of apprehension to the general public throughout the world.

ISSN:0971-1260
Vol-22-Issue-10-November-2019

Climate Cooling Gas (Anti Green House Gas)

However, other than the direct impact of these GHGs on the whole global radiation budget, there exists the most potent biogenic reduced sulphur gas, the Dimethyl Sulphide (DMS) having an indirect effect on reducing the atmosphere temperature. DMS is emitted in nature by phytoplankton and forms sulphate based aerosols and has a reasonable response in global climate regulation. It is primarily derived from a precursor compound, Dimethyl Sulphonio Propionate (DMSP), a major secondary metabolite found in certain classes of microalgae residing in the aquatic realm (Andrea et al 2007). The production of this organosulphur compound, DMS is having a significant impact on both the global sulphur cycle budget and regulating the pattern of CC (Charlson et al, 1987). Their involvement is mainly occupied in the atmospheric aerosol formation and consequent processes of acid precipitation and radiation balance of the Earth's atmosphere. More than 70% of the earth's surface are covered by Oceans and are having insightful power in the transport of this temperature cooling volatile sulphur gas globally from all the sectors of marine, coastal, and estuarine waters to accomplish in the atmospheric realm. The other ensuing natural gaseous forms of sulphur release to the air are Hydrogen Sulphide (H_2S), Carbon Disulphide (CS_2), Carbonyl Sulphide (COS), Methyl Mercaptan (CH_3SH), Dimethyl Sulphide, DMS (CH_3SCH_3). Among these sulphur sources, DMS is the most vital biogeochemical sulphur cycle component and possess second position to the atmospheric sulphur content, after the human activity related SO_2 emission from fossil fuel combustion as well as the industrial activities (Niffy, 2012). The biogenic volatile organic sulphur compounds including DMS diffuses into the atmosphere when it is oxidized to sulphur dioxide and combines with water vapor present in the air to yield Sulphate Aerosols (SA). These SAs turns into CCN, reflects back with incoming Sun's radiation into space, causing the indirect atmospheric cooling effect. The counter-effect of these volatile organic gases on GHGs is called the anti-greenhouse cooling gas. More production of DMS leads to give way to more SAs and in turn build up CCN, and ultimately back radiation mechanism develops. Consequently significant contribution to reflectivity and stability of cloud formation take place. Therefore this sulphur cycle participation proposes to act on regulating global temperature and control over CC. Hence the biological origin of DMS producing organisms is greatly highlighted as a signature for climate regulation. These concepts were commenced as "CLAW" hypothesis and postulated by four Scientists such as Charlson, Lovelock, Andreae and Warren (Charlson et al., 1987) and has become a milestones in the discipline of Atmospheric Science.

Air quality (AQ) and Atmospheric Pollution (AP)

Time passed and years of pollution on the ecosystem as a whole have taken place paving the way towards the nastiest condition of the environment. Drastic changes in the climatic pattern have happened over the years with a profusely large environmental pollution especially those from atmospheric air that we breathe even in a single minute! The pollution impacts play a pivotal negative and pathetic role for deteriorating the environment. All kinds of ill practices into

ISSN:0971-1260
Vol-22-Issue-10-November-2019

the ecosystem destroys the terrains, vegetations, kills the aura, and leaves of the present environmental niche and the future generations should face with even more deadliest diseases of which many are on towards the outbreak in vanishing the fauna and flora.

Urban AP are the resultant emission from a number of different sources mainly from industrial and domestic fuel combustion, both diesel and petrol vehicle emissions. The ambient AP is from the primary energy consumption source, where fossil fuels are the chief producer of dust, soot, and smoke. Nitrogen Oxides, sulfur oxides along with other suspended particulate matter are the chief climate forcing components. SO_2 and CO_2 are mainly attributed from fossil fuel use; NO_2 is a combustion derived gas; and the vehicular CO_2, CO emissions are also initiates to global warming. Motor vehicles and automobiles are the agents for emitting NO_x, CO, volatile organic compounds, toxic metals like Pb, Cd along with particulate matter of both $PM_{2.5}$ and PM_{10} (Fuzzi et.al 2015). The levels of these aerosol constituents are greatly increasing in urban and rural areas and drastically affecting the human health, vegetation, buildings, and historic monuments and finally go ahead to a catastrophic change in the weather and climate pattern in the whole Universe.

Air Quality Monitoring

Climate gases are characterized by their strong absorption contributions within the infrared spectral range making them effective in the process of trapping the long wave radiation escaping to space and hence influencing the Earth radiative budget. In addition to the water vapor contribution, the trace gases, such as CO_2, N_2O, CH_4, O_3, and CFCs are well known to be important contributors to the climate forcing and finally altering the climate. The CCNs role is to be studied in detail as this has a positive impact in the atmosphere by helping in bringing down the fast increasing temperature towards a considerable range (Dusck et al 2006,Denmen 2007).

Though for the past few decades, advanced technologies significantly throw light in the improvement of monitoring strategies and their understanding in the fate of these chemical constituent(Nair et al 2006, CPCB 2009, 2011 and 2012). Much changes are not witnessed in the field of air-quality related health menace and their remedial measures. The composition of the atmosphere is comparable to the perturbations resulting from industrialized emissions at northern temperate latitudes. The uncertainty of these tropical emissions, however, is considerably greater than the industrialized sources, which can be somewhat accurately deduced from fossil fuel usage and control over the emission of toxic trace gases into the atmospheric realm.

A geostationary satellite mission would greatly reduce the error associated with these emission estimates over the tropics. Differential absorption lidars offer the unique capability to see "through" the stratosphere and obtain information that is explicitly originating from the troposphere. Such systems have been successfully demonstrated from airborne platforms to measure ozone, water vapor, and aerosols (Pope et al 2009, Tsai et al 2015). When used in an atmospheric chemistry context, they would provide extremely better information about the

ISSN:0971-1260
Vol-22-Issue-10-November-2019

complex vertical structure of tropospheric trace gases than any passive technique. Such structure is necessary to obtain a better understanding of how trace gases are transported from local sources and how they eventually feed into global tropospheric trace gas budgets. The future of tropospheric chemistry measurements is central to future research achievements in the synthesis of atmospheric chemistry processes that transcend traditional atmospheric spatial and temporal scales (Zhang et al 2012). Through the use of a geostationary platform, the tropospheric chemistry community can learn much from a space borne scientific mission that will provide unique insight into the interaction of local, regional, national, and global pollution problems. Quantification of the emissions from biomass burning has been one of the most challenging problems in tropospheric chemistry and the use of space borne, and in particular, a geostationary platform which must be placed over the equator, provides the optimum vantage point from which to conduct tropical atmospheric chemistry studies. To date, all investigations concur that the contributions of biomass burning to global modifications of the both geostationary instruments and active sensors in space within a decade. Such instruments will be flown in that time frame which depends on how well the tropospheric chemistry community can have their pleas heard that these satellites should be the highest priority for future space missions. Earlier reports discuss the remote sensing of ambient air particles by means of both ground measurement along with the data from the Moderate Resolution Imaging Spectro radiometer (MODIS) in conjunction with satellites (Gupta et al 2006).

Aerosol and Health

Fine particulate matter (fpm) is one of the key components influencing a health impact on humans globally. Exposure to this pollutant causes an array of adverse respiratory effects including bronchi constriction and increased asthma symptoms (Barnett et al 2005, Chen et al 2005, Ulrich Posch 2005, Dockery 2013). The epidemiological studies on fpm and traffic related air borne particles enhance cardiovascular and allergic diseases. The inhalation of nitrated particles triggers immune reactions, promote the genesis of skin inflammations (Curtis et al 2006). Airborne particulate constituents are the causative agents for reproductive and development effects such as coronary heart disease, premature mortality and other cardiovascular bronchial diseases (Brook et al 2004, Maitri 2006). Many efforts should be taken care for reducing the effects of particulate matter and trace gases in the atmosphere for the better sustainability of ecosystem. (Kumar, 2008).

Conclusion

For the existence of better life in the society, climate is the paramount deciding factor which focuses on the quality of the air that we breathe every second. Both natural and anthropogenic activities leads to a change in the atmospheric aerosol content and cause a deviation in climate pattern. The deterioration of the atmosphere owing to the emanation of indigenous toxic aerosol species results in health-related problems like respiratory syndromes, skin allergies, and various cardiovascular diseases and so on. Measures have been undertaken by

ISSN:0971-1260
Vol-22-Issue-10-November-2019

reducing the discharge of black carbon, inorganic and organic aerosols, ammonia, and other trace gases including GHGs. Due to the spatio-temporal difference in the aerosol constituent create the AQ assessment tedious and non systematic processes throughout the world. Integrate AQ status records, climate change data sets along with the adaptation and mitigation efforts. Hence intensive intergovernmental collaborative network for AQ modeling and surveillance and management system could aid to develop AQ index for specific regions in each country and recognizing that the atmospheric and oceanic realm lies in the whole universe there by conduct awareness programme with specific futuristic aim for the public to lead a healthy environment. This will facilitate the AQ regulation stringently for the society to lead an aesthetic life in the future.

References

1. Andrea Gambaro , Ivo Moret , Rossano Piazza , Carlo Andreoli , Eleonora Da Rin , Gabriele Capodaglio , Carlo Barbante, Paolo Cescon a b, 2007. Temporal evolution of DMS and DMSP in Antarctic Coastal Sea water. International Journal of Environmental Analytical Chemistry. 84, 401-412.

2. Arnold, F. (2008). Atmospheric ions and aerosol formation. In Planetary Atmospheric Electricity,137, 225-239. Springer, New York.

3. Barnett, A. G., Williams, G. M., Schwartz, J., Neller, A. H., Best, T. L., Petroeschevsky, A. L.,Simpson, R. W. (2005). Air pollution and child respiratory health: a case-crossover study in Australia and New Zealand. American Journal of Respiratory and Critical Care Medicine, 171(11), 1272-1278.

4. Bhanarkar, A. D., Goyal, S. K., Sivacoumar, R., & Rao, C. C. (2005). Assessment of contribution of SO_2 and NO_2 from different sources in Jamshedpur region, India. Atmospheric Environment, 39(40), 7745-7760.

5. Boucher, O., Randall, D., Artaxo, P., Bretherton, C., Feingold, G., Forster, P., Kerminen, V.-M., Kondo, Y., Liao, H., Lohmann, U., Rasch, P., Satheesh, S. K., Sherwood, S., Stevens, B., and Zhang, X. Y.: Clouds and aerosols, in: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by: Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Doschung, J., Nauels, A., Xia, Y., Bex, V., and Midgley, P. M.: Cambridge University Press, United Kingdom and New York USA, 571–657, doi:10.1017/CBO9781107415324.016, 2013.

6. Brook, R. D., Franklin, B., Cascio, W., Hong, Y., Howard, G., Lipsett, M., & Tager, I. (2004). Air Pollution and cardiovascular disease - A statement for healthcare professionals from the expert panel On population and prevention science of the American Heart Association. Circulation, 109(21),2655-2671.

ISSN:0971-1260
Vol-22-Issue-10-November-2019

7. Charlson Robert J, James E. Lovelock, Meinrat O. Andreae ,Stephen G. Warren,1987 Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate Nature 326, 655–661

8. Chen, L.H., S.F. Knutsen, D. Shavlik, W.L. Beeson, F. Peterson and M.Ghamsary: (2005).The Association between fatal coronary heart disease and ambient particulate air pollution: Are females At greater risk? Environ. Hlth. Persp., 113, 723-1729 .

9. CPCB, (2009), National Ambient Air Quality Status 2008, New Delhi: Central Pollution ControlBoard, Ministry of Environment and Forests, Government of India http://cpcb.nic.in/upload/newitems/newitem_ 147_report-2008.pdf

10. CPCB (2011): National Ambient Air Quality Status, 2009, New Delhi: Central Pollution Control Board,Ministryof Environment and Forests, Government of India, http://cpcb.nic.in/upload/Publications/Publication _514_air quality status 2009.pdf

11. CPCB (2012): National Ambient Air Quality Status and Trends in India-2010, New Delhi:Central Pollution Control Board, Ministry of Environment and Forests, Government of India,http://www.cpcb.nic.in/upload/New Items/newitem_192_NAAQSTI.pdf.

12. Curtis, L., Rea, W., Smith-Willis, P., Fenyves, E., & Pan, Y. (2006). Adverse health effects of outdoor air pollutants. Environment international, 32(6), 815-830.

13. Denman, K. L., Brasseur, G., Chidthaisong, A., Ciais, P., Cox, P., Dickinson, R. E., Haugustaine, D., Heinze, C., Holland, E., Jacob, D., Lohmann, U., Ramachandran, S., da Silva Dias, P. L., Wofsy, S. C., and Zhang, X.: Couplings between changes in the climate system and biogeochemistry, in: Climate change 2007: The Physical Science Basis, edited by: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M., and Miller, H. L., 499–587, 2007.

14. Dockery, D. W., Rich, D. Q., Goodman, P. G., Clancy, L., Ohman-Strickland, P., George, P.,Kotlov, T. (2013). Effect of air pollution control on mortality and hospital admissions in Ireland. Research Report (Health Effects Institute), (176), 3-109.

15. Dusek, U., Frank, G. P., Hildebrandt, L., Curtius, J., Schneider, J., Walter, S., & Borrmann, S. (2006). Size matters more than chemistry for cloud-nucleating ability of aerosol particles. Science, 312(5778), 1375-1378.

16. Eleftheriadis, K. & Colbeck, I. (2001). Coarse atmospheric aerosol: size distributions of trace elements. Atmospheric Environment, 35(31), 5321-5330.

17. Forster, P. E. A.: IPCC Climate Change 2007, The Physical Science Basis

ISSN:0971-1260
Vol-22-Issue-10-November-2019

18. Fuzzi, S., Baltensperger, U., Carslaw, K., Decesari, S., Denier van der Gon, H., Facchini, M.C, Nemitz, E. (2015). Particulate matter, air quality and climate: lessons learned and future needs. Atmospheric Chemistry and Physics Discussions, 15(1), 521-744.

19. Gayathree Devi (2016) A Breakthrough Investigation on the Assessment of Aerosol Constituents in the realm of Kochi, Ph.D Thesis, Cochin University of Science and Technology, Kerala, India.

20. Gayathree Devi P.K, Akhil P.S and Sujatha, C.H (2016) Metal Signature of Atmospheric Aerosol from Kochi, the Queen of Arabian Sea, Kerala, India. Journal of Pollution, 2(3): 247–267.

21. Gupta, P., Christopher, S. A., Wang, J., Gehrig, R., Lee, Y. C., & Kumar, N. (2006). Satellite remote sensing of particulate matter and air quality assessment over global cities. Atmospheric Environment, 40(30), 5880-5892.

22. He,J., Gong,S., Yu, Y, Yu,L.Wu, L, Mao, H., Song.C., Zhao, S., Liu, H., Li,X., Li, R. 2017. Air pollution characteristics and their relation to meteorological conditions during 2014-2015 in major Chinese cities. Environmental.Pollution.223, 484-496.

23. IPCC: Fourth Assessment Report Climate Change 2007: The Physical Science Basis. Contribution ofworking Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M., and Miller, H. L.,Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp., 2007.

24. Jickells, T., An, Z., Andersen, K., Baker, A., Bergametti, G., Brooks, N., Cao, J., Boyd, P., Duce, R., Hunter, K., Kawahata, H., Kubilay, N., laroche, J., Liss, P., Mahowald, N., Prospero, J., Ridgwell, A., Tegen, I., and Torres, R.: Global iron connections between desert dust, ocean biogeochemistry, and climate, Science, 308, 67–71, doi:10.1126/science.1105959, 2005.

25. Kaushik, C. P., Ravindra, K., Yadav, K., Mehta, S., & Haritash, A. K. (2006). Assessment of ambient air quality in urban centres of Haryana (India) in relation to different anthropogenic activities and health risks. Environmental monitoring and assessment, 122(1-3), 27-40.

26. Kiehl, J. T. (1999). Solving the aerosol puzzle. Science, 283(5406), 1273.

27. Kim, S. W., Yoon, S. C., Jefferson, A., Ogren, J. A., Dutton, E. G., Won, J. G., Han, J. S.(2005). Aerosol optical, chemical and physical properties at Gosan, Korea during Asian dust and pollution episodes in 2001.Atmospheric Environment, 39(1), 39-50.

28. Kumar N, Chu A and Foster A 2008 Remote sensing of ambient particles in Delhi and its environs: estimation and validation, Int J Remote Sens. 2008 June ; 29(12): 3383–3405.

29. Lu, D., Xu, J., Yang, D., Zhao, J., 2017. Spatio-temporal variation and influence factors of $PM_{2.5}$ concentrations in China from 1998 to 2014. Atmospheric. Pollution. Research.*, 1151-1159. https://doi.org/10.1016/j.apr.2017.05.005

30. Manojkumar.N and Srimuruganandam.B, 2019. Assessment of gaseous emissions and radiative forcing in Indian forest fires. International Journal of Environmental Studies 76, NO. 4, 541–557 https://doi.org/10.1080/00207233.2019.1596387

31. Maitre, A., Bonneterre, V., Huillard, L., Sabatier, P., & de Gaudemaris, R. (2006). Impact of urban tmospheric pollution on coronary disease. European Heart Journal, 27(19), 2275-2284.

32. Mukhopadhyay, S., & Kreycik, P. (2008). Dust generation and drought patterns in Africa from helium-4 in a modern Cape Verde coral. Geophysical Research Letters, 35(20).

33. Nair, V. S., Babu, S. S., & Moorthy, K. K. (2008). Aerosol characteristics in the marine atmospheric boundary layer over the Bay of Bengal and Arabian Sea during ICARB: Spatial distribution and latitudinal and longitudinal gradients. Journal of Geophysical Research: Atmospheres (1984–2012),113.

34. Nair, P. R., George, S. K., Sunilkumar, S. V., Parameswaran, K., Jacob, S., & Abraham, A.(2006). Chemical composition of aerosols over peninsular India during winter. Atmospheric Environment, 40(34), 6477-6493.

35. Niffy Benny, Sujatha C H: Enrichment Of Sulphur Compounds In The Cochin Estuarine System: Sulphur Chemistry Of Cochin Estuarine System. 3 May 2012 05/2012; LAP LAMBERT Academic Publishing

36. Osan, J., Török, S., Beckhoff, B., Ulm, G., Hwang, H., Ro, C. U., & Fuoco, R. (2006). Nitrogen and sulfur compounds in coastal Antarctic fine aerosol particles—an insight using non-destructive X-ray micro analytical methods. Atmospheric Environment, 40(25), 4691-4702.

37. Pandey, J. S., Khan, S., Joseph, V., & Kumar, R. (2002). Aerosol scavenging: Model application and sensitivity analysis in the Indian context. Environmental monitoring and assessment, 74(2),105-116.

38. Penner, J. E., Andreae, M. O., Annegarn, H., Barrie, L., Feichter, J., Hegg, D., &Pitari, G.(2001). Aerosols, their direct and indirect effects. In Climate Change 2001: The Scientific Basis Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel On Climate Change (pp. 289-348). Cambridge University Press.

39. Pope, C. A., Ezzati, M., & Dockery, D. W. (2009). Fine-particulate air pollution and life expectancy in the United States. New England Journal of Medicine, 360(4), 376-386.

ISSN:0971-1260
Vol-22-Issue-10-November-2019

40. Ramanathan V (1987) The role of earth radiation budget studies in climate and general circulation research. Journal of Geophysical Research, 92, 4075-4095.

41. Ramanathan V, Cess R D, Harrison E F, Minnis P, Barkstom B R, Ahmad E and Hartmann D (1989) Cloud-radiative forcing and climate: Results from the Earth Radiation Budget Experiment. Science, 243, 57-63.

42. Rastogi, N. & Sarin, M. M. (2009). Quantitative chemical composition and characteristics of aerosols over western India: One-year record of temporal variability. Atmospheric Environment, 43(22), 3481-3488.

43. Rengarajan, R., Sarin, M. M., & Sudheer, A. K. (2007). Carbonaceous and inorganic species in atmospheric aerosols during wintertime over urban and high-altitude sites in North India.Journal of Geophysical Research: Atmospheres (1984–2012), 112(D21).

44. Saleeby, S. M., Cotton, W. R., Lowenthal, D., Borys, R. D., & Wetzel, M. A. (2009). Influence of cloud condensation nuclei on orographic snowfall. Journal of Applied Meteorology and Climatology, 48(5), 903-922.

45. Satsangi, A., Pachauri, T., Singla, V., Lakhani, A., & Kumari, K. M. (2013). Water soluble ionic Species in atmospheric aerosols: Concentrations and sources at Agra in the Indo-Gangetic Plain (IGP). Aerosol Air Qual Res, 13, 1877-1889.

46. Seinfeld, J. H., & Pandis, S. N. (1998). From air pollution to climate change. Atmospheric Chemistry and Physics.Sokolik, I., Darmenov, A., Choi, H., & Darmenova, K. (2008). Characterization of atmospheric mineral dust with remote sensing and the regional transport model WRF-dumo. In AGU Spring Meeting Abstracts Vol. 1, p. 03.

47. Small, J. D., Chuang, P. Y., Feingold, G., & Jiang, H. (2009). Can aerosol decrease cloud Lifetime. Geophysical Research Letters, 36(16).

48. Subhasish Ghosh, Tarun Gupta, Nikhil Rastogi , Abhishek Gaur , Amit Misra , Sachchida N. Tripathi , Debajyoti Paul , Vinod Tare , Om Prakash , Deepika Bhattu , Anubhav K. Dwivedi , Daya S.Kau , Rosalin Dalai , Sumit K. Mishra, 2014, Chemical Characterization of Summertime Dust Events at Kanpur: Insight into the Sources and Level of Mixing with Anthropogenic Emissions. Aerosol and Air Quality Research, 14: 879–891, 2014 ISSN:1680-8584 print / 2071-1409 online doi: 10.4209/aaqr.2013.07.0240

49. Sunderesan J (2011) Climate change impact– A novel, initiate for kerala, Indian Journal of Geo–Marine Sciences, 40(4), 483–486.

50. Tsai Ying I.1,2,3*, Khajornsak Sopajaree1 , Su-Ching Kuo4 , Ting-Yi Hsin2 ,2015 Chemical Composition and Size-Fractionated Origins of Aerosols over a Remote Coastal Site in Southern Taiwan. Aerosol and Air Quality Research, 15: 2549–2570ISSN: 1680-8584 print / 2071-1409 online doi: 10.4209/aaqr.2015.09.0566

ISSN:0971-1260
Vol-22-Issue-10-November-2019

51. Twomey, S. (1977). The influence of pollution on the shortwave albedo of clouds. Journal of the Atmospheric sciences, 34(7), 1149-1152.

52. Ulrich Poschl 2005 Atmospheric Aerosols: Composition, transformation, Climate and Health Effects. Angew.Chem.Int.Ed, 44, 7520-7540 doi:10.1002/ANIE.200501122.

53. Zhang, X. Y., Wang, Y. Q., Niu, T., Zhang, X.C., Gong, S.L., Zhang, Y.M., & Sun, J.Y (2012). Atmospheric aerosol compositions in China: spatial/temporal variability, chemical signature,Regional haze distribution and comparisons with global aerosols. Atmospheric Chemistry and Physics 12.2: 779-799.

54. HindustanTimes(https://www.patrika.com/ghaziabad-news/ghaziabad-becomes-highest-polluted-city-of-ncr-3642307/) . 31-10.2018