ENVIS NEWSLETTER

ENVIS CENTRE ON BIOGEOCHEMISTRY

(Supported by: Ministry of Environment & Forests, Govt. of India)

SCHOOL OF ENVIRONMENTAL SCIENCES

JAWAHARLAL NEHRU UNIVERSITY NEW DELHI, INDIA

Vol. 13 Issue No. 1 2007

Contents

FROM EDITOR'S DESK

In recent times climate change has been hogging the limelight in print and electronic media as this environmental issue is being researched, debated and discussed at numerous national and international fora by scientist, government officials, policy-makers, NGOs and the civil society. The reasons are not far to seek as climate change has political, social, economic, scientific and technical dimensions. Climate change is bound to have an impact among other things on biogeochemical cycle of various elements. In addition to greenhouse gas emissions, aerosols are also known to be agent of climate change. Their role is biogeochemical cycle of chemical elements can not be underestimated. It is in this context that the present issue of the news letter introduces some introductory concepts about aerosols. Also biogeochemical aspects of Sunderban mangrove ecosystem are presented in this letter.

In addition, in present news letter covers list of recent research publications on biogeochemistry, aerosols, greenhouse gas, climate change, and fourth coming conferences/ workshop on environmental issues.

Prof. V.K. Jain
Editor

Biogeochemistry is a broad, diverse and truly an interdisciplinary research field involving biological, geological and chemical aspects. Biogeochemical cycle means a cycle /path/route through which chemical element /molecules/ compounds move through both biotic ("bio") and abiotic ("geo") compartments of the earth system. These cycles include both the living biosphere, and the nonliving lithosphere, atmosphere and hydrosphere. The term biogeochemical is self-explanatory: bio- refers to biosphere, geo- refers collectively to the lithosphere, atmosphere and hydrosphere and chemical refers to the chemical that follows the cycle. In addition to the regular cycling process of elements, sink/ reservoir stage is also encountered during the elemental biogeochemical cycling where these elements are locked or accumulated for a longer period (geological time scale) e.g. C in coal/fossil fuel deposits. It is to note here that elements cycle in a closed system, which reveal the fact that they are only recycled instead of lost or replenished as in the case of an open system. The timing for the cycling of elements is a function of the nature of the different components of geosphere (Figure- 1). Atmosphere plays a crucial role in biogeochemical cycling of elements in a way that the cycling process and time needed is minimum compared to the other spheres. In the present issue, we focus on basic properties of aerosols, as aerosols play a crucial role in cycling of elements via their omnipresent existence in atmosphere.

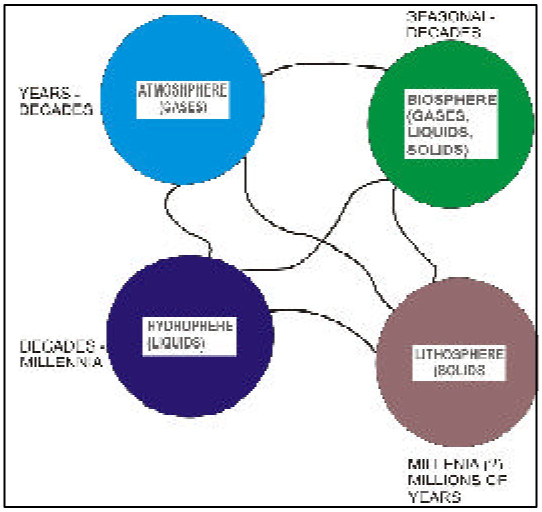

Figure 1 : Role of different spheres of the in earth system in Biogeochemical cycling of elements

Atmospheric aerosols are ensemble of all liquid/solid particles suspended in the atmosphere, except cloud droplets/ water/ ice clouds/ ice crystals. Note that the ensemble Water and Ice clouds are conventionally excluded because of their tight involvement with the hydrological cycle, short lifetimes and involvement in long- range latent energy transport.

Aerosols or Dust ? These two terms are used as synonymous inadvertently but there lies a difference. All solid material suspended in air can be called as dust (coarse or fine depending upon size of the particles) but all dust can not be called as aerosol because dust includes both type of solid particle which are in suspension and the one which has been deposited on earth surface. One should be cautious while using these terms. **Physically Aerosols are** poly-disperse in nature and follow log normal distribution of size. The size varies over five order of magnitude (10^{-3} to 10^{2} µm) depending on source, source history, generation and post formation processes. **Chemically** composition depends on size, source and generation processes. In general finer aerosols come from anthropogenic sources whereas crustal sources dominate in coarser fractions. **Biologically** fine aerosols are carrier of pollens, fungal spores, bacteria, mites, plant fragments, and allergic diseases, such as aerosols are called Bioaerosols. Further more the type and nature of aerosols are recognized strictly on the basis of their size, origin, formation mechanism, chemical composition, atmospheric behavior. The size of particles is given on the basis of their diameters which are again of the following types:.

1. **Equivalent volume diameter**: diameter of the sphere having same volume as the given irregular particle
2. **Stoke's diameter**: diameter of the sphere having same density and terminal settling velocity as the given particle
3. **Aerodynamic diameter**: diameter of the sphere of unit density but having same terminal settling velocity as the given particle (useful for characterizing filtration and respiratory depositions), by convention we are using aerodynamic diameter in our present studies.

Types of Aerosols on the basis of their size (aerodynamic diameter) with their residence time in atmosphere:

Free Fall - Falling freely under gravity DUST: 100µm

Dust also means deposits of such materials, settle quickly with gravity effect due to their large size

Suspended Particulate Matter - (SPM: 0.05-100µm) remain in suspended in atmosphere few days

PM_{10} - Particles less than 10 µm stays in atmosphere for weeks or months

Both SPM and PM_{10} (particle <0.05µ) can be subjected to long range impact depending upon the metrological parameter such as wind velocity, direction, humidity present in the region. The long range impact of aerosols from continent to continent, intercontinental or from ocean to continent is well studied and documented.

Mass concentration of particles collected by a sampler with a 50% cut-point at an aerodynamic particle diameter of 10 micrometers. This represents mostly particles with aerodynamic particle diameters of 10 micrometers or less.

$PM_{2.5}$: Mass concentration of particles collected by a sampler with a 50% cut-point at an aerodynamic particle diameter of 2.5 micrometers. This represents mostly particles with aerodynamic particle diameters of 2.5 micrometers or less.

Nomenclature is also a function of property to be studied:

METEOROLOGICAL STUDIES

According to Junge

Aitken particles	:	from approx. 1 nm to 100nm
Large particles	:	from 0.1 μm to 1μm
Giant particles	:	larger than 1 μm up to approx. 100 μm

According to Whitby

Nucleation mode particles	:	from 1 nm to 100nm
Accumulation mode particles	:	from 0.1 μm to 1μm
Coarse mode particles	:	larger than 1 μm up to ~ 100 μm

AIR ELECTRICITY STUDIES

Small ions	:	approx. 0.1 nm
Large ions	:	from approx. 1 nm to 100 nm

ATMOSPHERIC OPTICS STUDIES

Haze particles: approx. 10 μm to ~ 1 μm

CLOUD PHYSICS

Active condensation nuclei : approx. 10 nm to ~ 1 μm

AIR CHEMISTRY AND POLLUTION STUDIES

Particles containing main aerosol mass: ~ 100nm to ~ 10 μm

Aerosol distribution in atmosphere is dominantly studied with refers to their volume, size of particles and number distribution as well as their properties under this study (Figure 2)

Number distribution (Cloud formation)

Surface distribution (Visibility Study)

Volume & Mass distribution (Health Study)

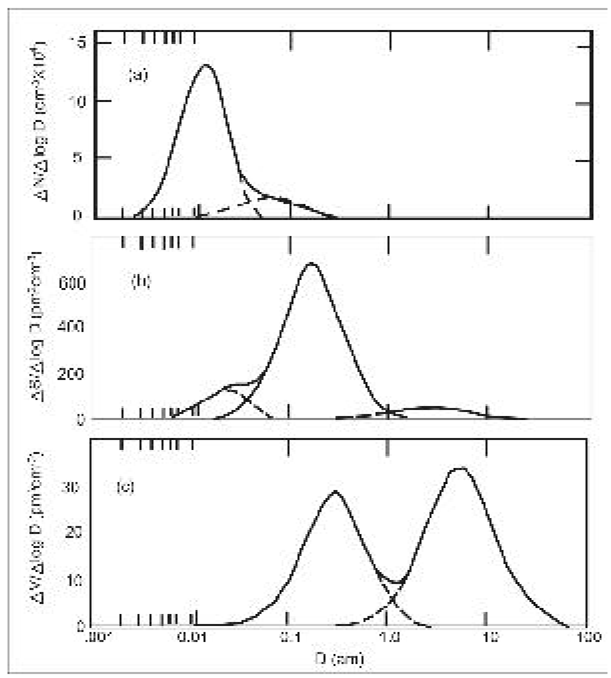

Fig 2: Figure showing the mass, number and volume distribution of aerosols with their size and the related property of interest.

<u>Volume / Size/ Number Distribution</u>

If our concern is to study the **mass** of some pollutant that is being transported through the air for biogeochemical cycles, then we want to know the mean diameter of the particles with the mass or **volume**. In other words, "**What size particles carry the most mass**?"

If our concern is to study the loss of **visibility** then we want to know the diameter of the particles that have the largest cross section or **surface area become important**. In other words, "**What size particles cover the largest surface area?"**

If our concern is to study the **cloud formation or microphysics** then we want to know the range of diameters with the largest **number** of particles. In other words, "**What is the size of the most abundant particles?"**

If our concern is to study **human health** effect of aerosols then we need to know about both the **mass and number** of the particles, because **only a certain size particle can enter the lungs**

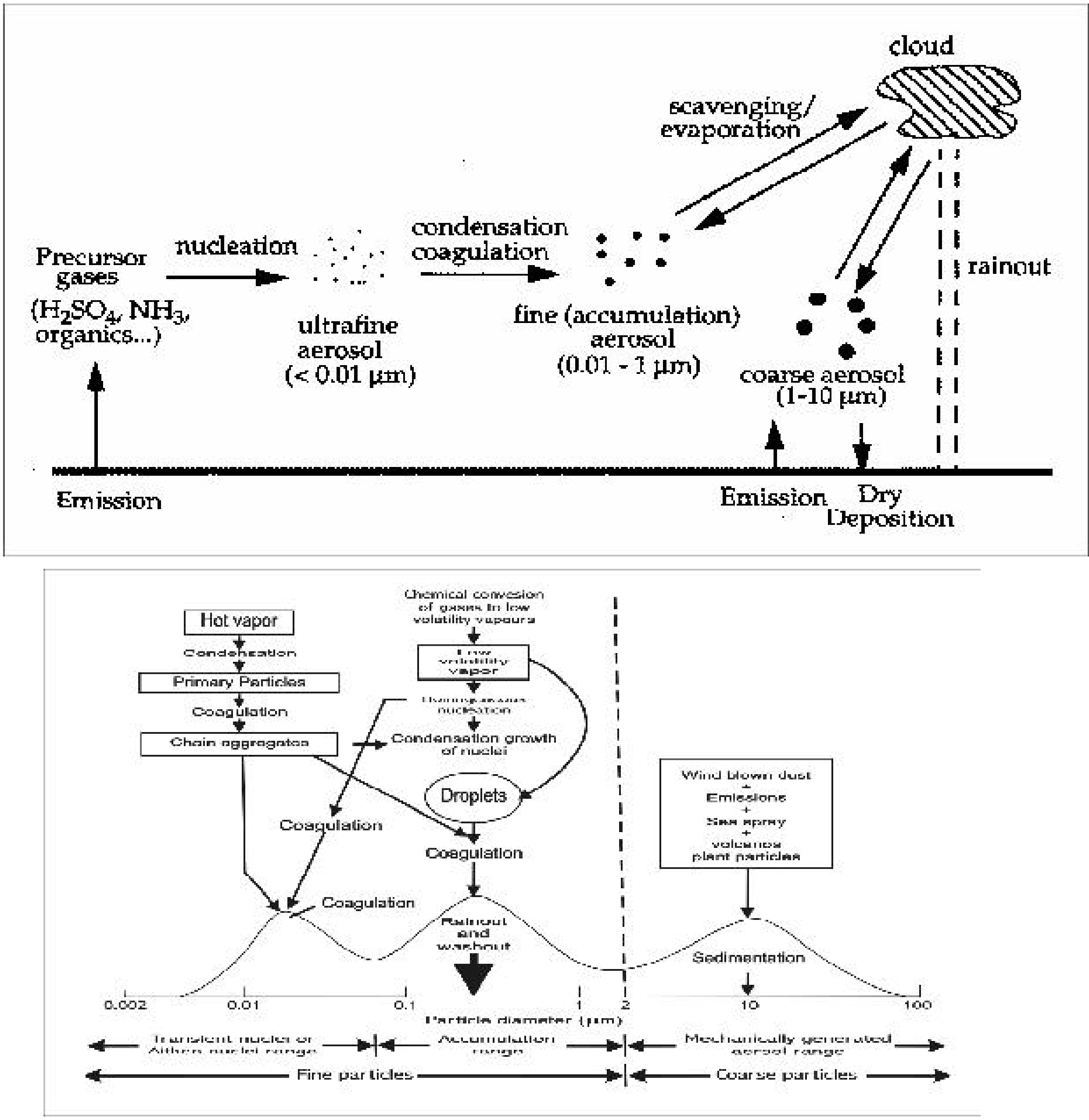

Figure 3 A and B: Depicting the different sources and processes involved in aerosol generation in different size fractions.

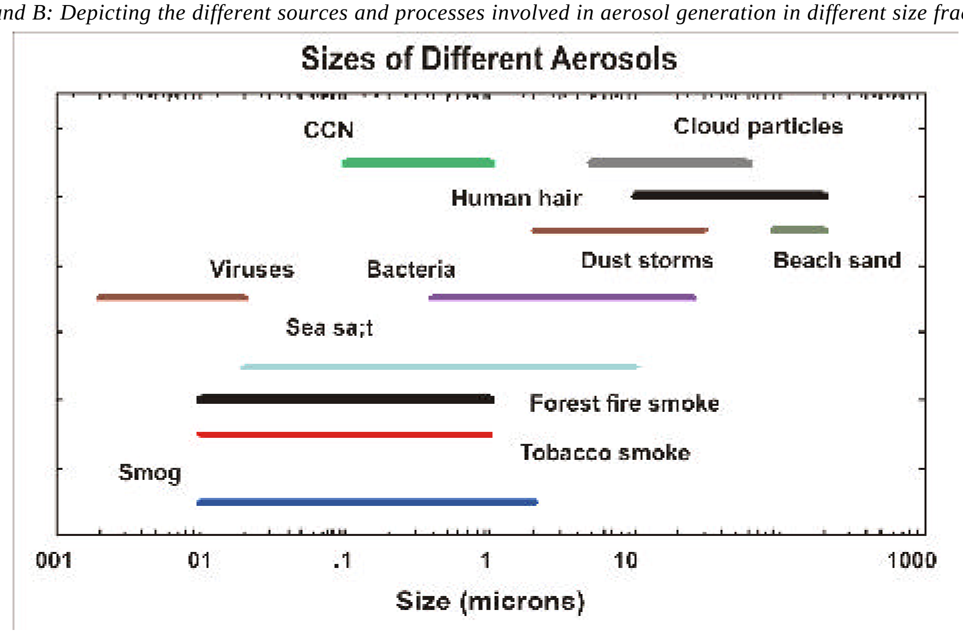

Figure 4: Showing size range of aerosol particles generated from different sources.

Abundance and size

- Aerosol concentration is highly variable in space and time. Concentrations are usually highest near the ground and near source(s).
- A concentration of 10^5 cm^{-3} is typical of polluted air near the ground, but values may range from 2 orders of magnitude higher in very polluted regions to several lower in very clean air.
- Radii range from ~ 10^{-7} cm for the for small ions to more than 10 µm (10^{-3} cm) for the largest salt and dust particles.
- Small ions play almost no role in atmospheric condensation because of the very high super-saturations required for condensation.
- The largest particles, however, are only able to remain airborne for a limited time

Sources and Processes:

Origin of aerosols:

Aerosols are generated dominantly by four process

- Condensation and sublimation of vapors and the formation of smokes in natural and man-made combustion,
- Reactions between trace gases in the atmosphere through the action of heat, radiation, or humidity,
- The mechanical disruption and dispersal of matter at the earth's surface, either as sea spray over the oceans, or as mineral dusts over the continents and
- Coagulation of nuclei which tends to produce larger particles of mixed constitution.

Main Types of Aerosols

- Continental/ Desert Aerosols
- Marine Aerosols
- Industrial Aerosols
- Volcanic Aerosols
- Organic Forest Hazes
- Smoke/Biomass Burning Aerosols
- Stratospheric Aerosols

Estimates of annual global production of aerosols by different sources

NATURAL SOURCES	**QUANTITY (Tg/Yr)**
Rock and soil debris	100-1500
Forest fire	3-150
Sea salt	300
Volcanic debris	25-150
Particles by gas to particle conversion:	
Sulphate from hydrogen sulphite	0-200
Nitrate from nitrogen oxides	60-430
Hydrocarbon from plants	75-200
Sub-total (natural)	***693-2630***
ANTHROPOGENIC SOURCES	**(~20-25%)**
Directly emitted particles	10-90
Particles by gas to particles conversion:	
Sulphate from sulphur dioxide	130-200
Nitrate from nitrogen oxides	30-35
Hydrocarbon	15-90
Sub-total (anthropogenic)	***185-415***
GRAND TOTAL	**878-3045**

A summery of characteristic elements emitted from various sources is given in the following:

Emission Sources	**Characteristic Elements Emitted**
Resuspended soil	Si, V, Cr, Ca, Ti, Sr, Al, Mn, Sc
Road transport	
Motor vehicle emissions	Br, Pb, Ba, Mn, Cl, Zn, V, Ni, Se, Sb, As
Engine wear	Fe, Al
Catalytic converters	Rare earths
Tyre wear	Zn
Road side dusts	C, Al, Si, K, Ca, Ti, Fe, Zn
Small combustion	
Refuse incineration	Zn, Sb, Cu, Cd, Hg, K, Pb
Wood smoke	Ca, Na, K, Fe, Br, Cl, Cu, Zn
Industrial facilities	
Oil fired power plants	V, Ni
Coal combustion	Se, As, Cr, Co, Cu, Al, S, P, Ga
Refineries	V
Nonferrous smelters	As, In, Cu, Zn
Iron and steel mills	Pb

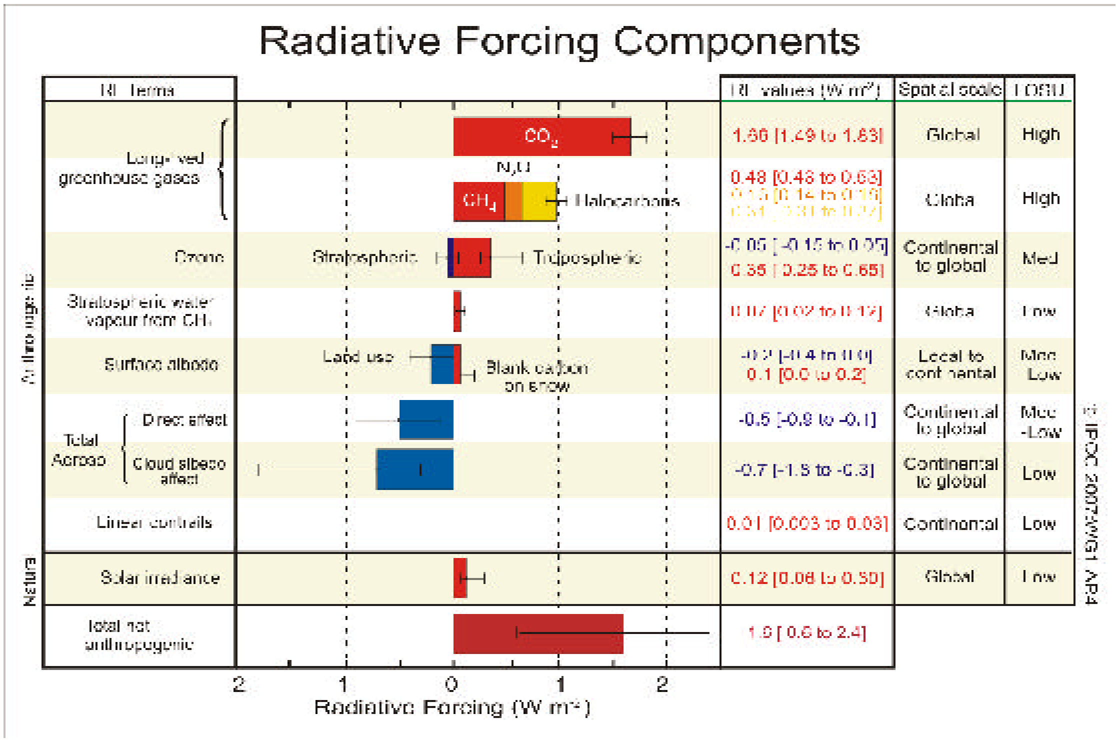

Figure 5: A comparison of radioactiv forcing (RF) due to aerosols with other RF terms is given in the table above.

Copper refinery	Cu
Minerals and material processing	Mg, Al, K, Sc, Fe, Mn
Sea spray	Na, Cl, S, K

Transport: Aerosols are transported by prevailing wind and convection once they are in the atmosphere. For this reasons, the elements contained in aerosols are seldom deposited on the surface of the earth in the same location that they were produced. The dry or wet deposition of aerosols can serve as source of elements to an ecosystem distinct from other sources, such as weathering. When sulfate (SO_4^{-2}) and (NO_3^-) containing aerosols are incorporated in cloud droplets, they lead to acidic deposition, often hundreds of miles away from the source of the aerosols or precursor gases. Although aerosols are produced by myriad natural processes, human activities are responsible for generating much of the aerosol load in todays atmosphere. Biomass and fossil fuel burning, agricultural activities, desertification, and industrial pollution all inject aerosol particles directly into the atmosphere (examples of primary production), or produce precursor gases that condense in the troposphere or stratosphere to form aerosols (example secondary production).

Importance of aerosols:
Aerosols in the environment have implications and important consequences in Climate change, air pollution, health effects (through respiration of direct inhalation), visibility, radiative balance, cloud formation, heterogeneous reactions, ecosystem processes and nutrient dynamics.

Air quality: Respiratory distress, eye irritation, Reduction of visibility, Acid rain

Figure 4: Showing size range of aerosol particles generated from different sources.

1. Climate:

Direct: scattering [cooling] and absorption [warming] of solar and infrared **Radiation**
Indirect: modify clouds properties
1st : brighter clouds
2nd : decrease precipitation efficiency

2. Biogeochemistry:

- Source of nutrient [Fe] in ocean
- Nutrient Dynamics and desertification

3. Atmospheric Chemistry:

- Heterogeneous reactions
- Reduction of photolysis rates
- Reduce/Increase GHG's Warming,
- Affect Cloud and Rain,
- Active in Atmospheric Chemistry,
- Supply Minerals to Ocean Biosphere,
- Affect Well- Being of Organisms on both Land and Sea:

Contain Spores, Microbes and Viruses, Acids and other stuff

Mangroves occur between transitional zone in between land and sea in approximately 75% of the tropical coast. The term Mangrove denotes both the Saline Plants (Halophytes) and the saline intertidal zone where they grow. Mangroves are salt tolerant trees and shrubs community that colonizes the sheltered marine shores and estuaries of tropical and sub-tropical regions. They generally occupy the region between the highest tidemarks and up to some extent of mid-tide level, the interfacial zone of water and land. Mangroves play an important role in the energy and nutrient cycles in tropical coasts and can represent an important source of organic material for many coastal organisms (Odum and Heald, 1975).

Mangrove ecosystems are considered to be very effective ecosystem. The primary productivity is very high. This high productivity often attributed to high litter degradation rates and efficient cycling of nutrients, which are supplied by autochthonous inputs from the natural and anthropogenic source. Approximately ten percent of litter produced is directly consumed and remaining bulk enters into detritus system. The fresh water of low nutrient value is decomposed through a physical, chemical and biological process and thus the transformation of organic materials to more nutritious form occur by microbial enrichment process. The nutrients remineralized by this process are then available for primary production.

Mangrove root morphology is highly adaptive nature: stilt root, pop root, butted root, aerial root, pneumatophores etc. due to various configuration of the substrate. Mangroves (Halophytes) grow at the best in deltaic tropical shoreline with fine grain sediments. Most suitable areas are with abundant rainfall with enormous discharge of fresh water (Chapman 1976). Lugo and Suedakar (1974) classified mangrove into four types; over washed forest forest, Dwarf (Shrub) forests, Hammock forest and Fringe forest. Over washed mangroves are lying along low lying Islands in shallow Bays ans islands and exposed to high wave activity and characterize by low export of organic matter. Dwarf mangroves occupy the flat coastal fringes and represent vegetation under stress. These are low productive wetlands. Hammock mangrove forest growth is determined by upland water runoff and grows in reducing environment on a substrate i.e., characterized by peat formation. In contrast to three above mentioned types,Fringe mangroves are characterized by tall trees, high biomass productivity, accumulation of litter, abundant resident as well as tidal migrant fauna. Well-developed prop root system traps much organic matter and sediments. Thus they act as protector against erosion and retard excessive siltation in inshore areas (Wolanski et al 1990).

Sunderban is an active delta /estuary of India and Bangladesh. It is formed by fluvial activity of Ganga and Brahmaputra River, at the mouth of Bay of Bengal. It's portion in India (West Bengal) is located between 21°30′N- 22°15′N latitude and 88°11′E- 89°10'E longitude with affirm network of tidal river channels, mudflats, sand flats, coastal dunes, creeks and islands. Sunderban tidal estuary comprises an area of 4282sq. km., of which tidal and intertidal mangrove area is estimated of 2328sq. k.m. (Bose). Altitude 5.8 m to 6.1 m above M.S.L. Average annual 1920.30 mm. The three main season of this region are winter (October to January), summer (February to May) and Monsoon (June to September). Minimum temp 20° C and maximum temperature 33.88° C (Gopal et al 2006).

Soil:

Wetland soils form in a variety of climates and parent materials they represent a broad spectrum of morphological properties and morphological characteristics and taxonomic classes and can be dominated by inorganic and organic materials. However wetlands soils have in common the condition of prolonged saturation. That means condition of zero or positive hydraulic head during which water would flow into unlined anger holes and a high proportion of pore space would be filled with water this condition forever-certain physical, chemical, biological and morphological tendencies that differentiate wetland soils from its upland counterparts. (Corstanje et all 2007)

The soil of this East coast is predominant with alluvium and in some areas behind this zone are in association with sandy alluvium. Sunderbans the deltaic region of Ganga is being constantly influenced by saline tidal water. The soil is mainly composed of alluvium enriched with clay, silt and sand particles. These soils are very fertile ,rich in nitrogen and phosphoric acid. The extent of these soils are also found along the creeks and canals several Km in width and in the shore line up to the zone of saline tide water flow. Topographically this region less than 5 meter from Mean Sea Level (MSL). Alluvial soil along this region have configuration and seasonal salinity condition depending upon the saline tide water influence associated with the changing level saline water thus usually named as "coastal saline alluvium soil " (Banerjee et al 2002).

Physical properties:

Saturation causes a number of physical changes in the soil including: Softening of the soil material as a result of weakening effect of water on the bonds holding soil particles as stable aggregates- Flooding forms dark soil which enhances heat absorption, increased water content also increases heat conductivity i.e., saturate soils bulk density (weight of dry soil per unit volume). Density is usually decreased due do constant flooding ranges between 0.3-1.5 and 0.1-1.0 cm^{-3}, low values typically observed in organic rich soil. This is due to high absorption capacity of organic matter and destruction of soil aggregates

Chemical properties:

Silty clay dominated textural soil enriched with sodium chloride ,sodium sulfate and organic matter . OM content ranges from 0.61-1.25%. Soils were slightly acidic and alkaline and are subjected to wide seasonal variation. Soil micronutrients study of this region shows the electrical conductivity ranges from 30-31 mmho/cm. The sediments were dominated by microcline, chlorite and mica (essentially muscovite). The acidification of soil transforms sulphide into sulphate with the release of sulphuric acid. Sulphur content of these soils is less than 5%. Magnesium found to be dominant and is followed by calcium, sodium and potassium (Banerjee et al 2002).

Nutrients:

Living organisms require the availability of 20-30 chemical elements for different physiological and metabolic process. Some of the organic substances like protein, hormones, amino acids possesses a complex structure in chemical formulation, they subsequently requires numerous different nutrients. Nutrients are classified into two major groups as per their quantitative requirements. Elements required in relatively large amount constitute more than 1% of the dry weight termed as macronutrients, this include carbon, hydrogen, oxygen, nitrogen and phosphorus. Some of macronutrients constitute 0.02-1% of dry- weight of organic matter including sulfur, chlorine, molybdenum, potassium, sodium, calcium, magnesium and copper. Nutrients those are found in trace amounts are generally termed as micronutrients. These are found in less than 0.2% of the total dry-weight of organic matter. Some of the micronutrients are: Aluminum, boron, chromium, cobalt, fluorine, gallium, iodine, manganese, selenium, strontium, tin, titanium, vanadium and zinc. Important nutrients enter into ecosystem mainly by four processes: 1.Weathering. 2. Atmospheric unit. 3. Biological nitrogen fixation. 4. Immigration (animal activity). Nutrient looses from ecosystem also by four means 1. Erosion. 2. Leaching. 3. Gaseous loss and 4. Immigration and harvesting.

Nutrients constitute one of the abiotic bases sustaining the development of every ecosystem. In the case of mangroves, the influence of hydrodynamical factors such as tides, currents or river discharge can be critical for nutrient supply and, to a great extent, determine the ecosystem structure and dynamics. Cations such as potassium, magnesium and Cations such as potassium, magnesium and calcium are known to play an important role in the ecophysiology of plants. In mangrove ecosystems, the concentrations of these cations have been found to influence the vegetation structure significantly. Potassium and calcium ions are probably responsible for developing salt tolerance of mangroves, their limits of migration being dependent on their capacity to increase the uptake of these cations and to reduce the uptake of sodium and chloride ions. Besides micronutrients such as nitrogen and phosphorus, macronutrients such as potassium, magnesium and calcium also have a significant role in regulating primary production and the distribution of algae. Calcium and magnesium have been found at high levels in bluegreen algae.

Compared to all other ecosystem mangrove ecosystem is considered to be one of the most productive ecosystems. Most of the coastal soil shows an accumulation of organic carbon. Accumulation of organic carbon in a result of balance between two processes 1.Carbon fixation through photosynthesis and 2. Release through decomposition. Generally the rate of photosynthesis is higher and rate of decomposition is lower due to anaerobic condition here. General tendency of organic carbon accumulation is observed here. The estimated mean primary productivity in a wetland ecosystem found to be approximately 1,300 gm cm^{-2} yr^{-1} (Houghton and Skole 1990). Whiting and Chanton (1993) estimated that approximately 3% of the net ecosystem production in wetlands escapes to atmosphere as methane. The rates are high due to location and vegetation.

Phosphorus is essential nutrient for living organisms. It is an essential component of nucleic acids and many intermediary metabolites. Mangrove sediments are expected to contain a high proportion of organic phosphorus compounds due to their high organic matter content (Boto, 1988). In general the capacity of mangrove sediments to immobilize phosphate depends on the amount of organic matter, C: P ratio, and the type of clay mineral present. Dissolution of mineral phosphate also depends on the physicochemical properties of such pH, available sulphides, alkalinity and redox state. These factors can of course be affected by the activity of microbes and larger organisms (Singh et. al., 2005).

Preliminary study on Nutrients shows that this mangrove of Sunderbans is under stress due to anthropogenic as well as geomorphic evolution of the delta which results in the lack of fresh water input and enhanced contamination level in water. Salinity showed dominance throughout the estuarine-deltaic system and as a result causing threat to natural regeneration of various salts intolerant species. Polluted waters causes dwarf ness in species in some places. In order to preserve this vulnerable ecosystem, there is a need for an urgent measure to increase the fresh water input in the river by clearing the chocked waterways or by managing the adjoining water sheds around this ecosystem.

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Some Recent Publication in Journal Related to Environmental Biogeochemistry

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