Literature review

An Overview

Global warming has been one of the world-wide issues and problems to be faced by human. Although some atmospheric processes are important for the removal of several GHGs, particularly methane, these processes are more difficult for human to control. Increasing rate of the atmospheric content of GHGs escalates Global warming (Forster and Ramaswamy, 2007). Global warming is the assessment, management and mitigation for contributing sources and sinks to global climate change, which intensify global temperature by approximately 0.76 ± 0.19°C since pre-industrial times. Primarily as a result of increased atmospheric concentrations, the greenhouse gases, CO₂, N₂O, CH₄, O₃ and halocarbons, accelerated due to result of human activities (Fest et al 2009). Moreover, anthropogenic activities contributed to large proportion of CO₂, N₂O and CH₄ emissions (Mosier et al., 2004). The agricultural and terrestrial ecosystems are important sinks for many GHGs. For example, plant biomass and soil are the major sinks of atmospheric CO₂.

2.1. Soil-atmosphere exchange of GHG emissions

The Carbon dioxide (CO₂), methane (CH₄) and nitrous oxide, (N₂O) are the key greenhouse gases (GHG) that contributed, towards the global warming at 60, 15 and 5%, respectively (Li et al., 1997). Quantification of GHG emissions from soil is needed for global modeling studies in the perspective of ecosystem modification and climate change. The N₂O, CH₄ and CO₂ soil-atmosphere exchange and controlling environmental factors were investigated for a 3-month period (dry-wet season transition) at the Kakamega Rain forest, Kenya, Africa. Moreover, Yao et al. (2010) and Mosier (2004) suggested the many evidences related to CH₄ consumption and sink in forest soil. Hui Wang et al (2010) studied the seasonal and temporal variation and the first concurrent measurements of soil-atmosphere exchanges of N₂O, CH₄ and CO₂ in four adjacent mono specific plantations of indigenous tree species of Pinus massoniana (PM), and the three broadleaf plantations Castanopsis hystrix (CH), Michelia macclurei(MM) and Mytilaria laosensis(ML) in subtropical China. Yan et al. (2008) used closed chamber system to measure fluxes of NO and N₂O from soil surfaces. The soil nitrogen and NO flux increased significantly after applying nitrogen
fertilizers into agricultural fields. Tang et al. (2006) recorded magnitude, temporal, and spatial patterns of greenhouse gas fluxes from soils of plantations in the subtropical area of China. They observed higher CO$_2$ and N$_2$O emission in the orchard site, however, there was no clear differences in CH$_4$ emissions between two sites. Seasonal changes and precipitation effects investigated on the variations of greenhouse gas emission (Inubushi et al.2003). Besides, CH$_4$ was observed higher in between February–April than the rest of year in tropical peatland in South Kalimantan, Indonesia. The seasonal variation of CO$_2$ flux was more pronounced in the boreal and temperate forests than in the tropical and subtropical forests, whereas, higher CH$_4$ uptake and emission were reported in the boreal and temperate forests in summer and winter, respectively (Fang et al. 2009).

Nirmal Kumar et al. (2014) analyzed CO$_2$, CH$_4$ and N$_2$O fluxes, from Eucalyptus plantation varied from -65.27 to 14.6, -0.005 to 0.07 and -0.03 to 0.33 mg m$^{-2}$ h$^{-1}$ respectively and correlated with soil temperature and soil water filled pore space. Nirmal Kumar et al. (2010) investigated CO$_2$, CH$_4$ and N$_2$O fluxes emission and global warming potential from soil under a tropical dry deciduous forest and Eucalyptus plantation Central Gujarat, Western India measured at fifteen days intervals using closed static chamber technique and gas chromatography method. They carried out soil CH$_4$ uptake maximum in April and minimum in February. The soils in the Dry deciduous forest had the potential to emit less N$_2$O (0.15 mg N m$^{-2}$ h$^{-1}$) than Eucalyptus plantation soils (0.18 mg N m$^{-2}$ h$^{-1}$). They postulated relationships between soil CO$_2$, CH$_4$ and N$_2$O fluxes, and soil temperature and soil water filled pore space (WFPS) in the deciduous forest and Eucalyptus plantation.

Moreover, Nirmal Kumar and Shailendra Viyol (2009) measured CH$_4$ emission in relation to chemical parameters like organic carbon, sulphate, phosphate of two rice fields and wetlands of central Gujarat, India and stated the methane emission ranged from 105.67 to 720.64 mg m$^{-2}$ hr$^{-1}$ having maximum emission during noon period (11.00 am to 1.00 pm) of the day at the rice field-1. Besides, at rice field-2, the methane emission ranged between 201.59 to 430.94 mg m$^{-2}$ hr$^{-1}$, having maximum peak during day period. Only a few studies (Yan et al., 2005; Li et al., 2005) have attempted to calculate detailed regional GHG emissions.
The CO₂ and N₂O emissions were mainly affected by soil temperature and soil moisture. Christina et al. (2010) carried out the fluctuations of greenhouse gases emissions, soil properties and monitored CO₂, CH₄, and N₂O fluxes, soil temperature (T), thermal conductivity (K), resistivity (R) and thermal diffusivity (D) from 2004 to 2006 in a pasture. The CO₂ and CH₄ were highest, but N₂O as well as T, K and D were lowest during 2004. Only K was correlated with CO₂ in 2004 while T correlated with both N₂O (r = 0.76, p = 0.0001) and CO₂ (r = 0.88, p = 0.0001) in 2005. In 2006, all gases fluxes were significantly correlated with T, K and R when the data for the entire year were considered. K and R offer a promise as potential controlling factors for greenhouse gases fluxes in this pasture. Besides, Kurganova et al. (2003) explored the annual and seasonal characteristics of CO₂ emission from five different ecosystems in situ (Russia, Moscow Region). The annual behaviour of the soil respiration rate is influenced by weather conditions in a particular year. The CO₂ fluxes comprised approximately 48–51% in summer, 23–24% in autumn, 18–20% in spring and 7–10% in winter of the total annual carbon dioxide flux.

2.2. Edaphic Factors Interrelation with Soil- atmosphere exchange of GHG emissions.

Greenhouse gas emissions are generated through different anthropogenic activities include land change, land use in the forests as well as agriculture systems, urbanization and industrialization. These activities disturb the N and C cycles in the terrestrial environments (IPCC, 2007). All most all CO₂, N₂O and CH₄ emissions are depend on the different microbial process and decomposition of organic resides in the soil. The contribution of agricultural soils to CO₂, N₂O and CH₄ emissions depends on the biophysical processes, and the incorporation/ decomposition of organic residues in the soil. The soil aerobic conditions produce CO₂, while anaerobic conditions produce CH₄, and nitrification and denitrification processes of mineral-N result to N₂O emission. Smith et al. (2010) examined the interactions between soil physical factors and the biological processes responsible for the production and consumption in soils of greenhouse gases. Moreover, Burger and Jackson (2003) indicated that soil N transformation rates were significantly higher in agricultural land with greater availability of organic substrates than in soils with lower substrate availability.
Fang et al (2009) observed the effects of soil moisture, temperature, bulk density and particle density on CO$_2$ emission and CH$_4$ uptake from old-growth forest soils in Boreal coniferous forest, Temperate needle-broad leaved mixed forest, Subtropical evergreen broad leaved forest and Tropical monsoon rain forest along eastern China. Apart from that, they also highlighted that, soil CO$_2$ and CH$_4$ fluxes were driven by many environmental factors including availability and amount of C substrates, temperature, and soil water content, redox potential and aeration, diffusion, soil texture, soil pH, salinity, ion deficiencies and toxicities and elevated CO$_2$ and atmospheric N deposition (Dalal and Allen 2008).

Broken and Beese (2006) explained CH$_4$ emission from wetland and CH$_4$ uptake in upland soil. Moreover, Yan et al. (2008) concluded that soil CH$_4$ is influenced by soil moisture and inversely correlated by soil temperature. Three treatments were set in the studied field: (A) litter-free, (B) with litter, and (C) with litter and seedling. A strong positive relationship occurred between CH$_4$ fluxes and soil moisture in all the three treatments, and weak relationship between CH$_4$ fluxes and soil temperature for treatment B and treatment C. The N$_2$O fluxes correlated with soil temperature for all the three treatments.

Smit et al. (2010) explained the interactions between soil physical factors and the biological processes responsible and observed the significant correlation between the greenhouse gas emissions with moisture content, pH, organic matter, temperature, water filled pore space. Moreover, the emission of CO$_2$ from soil organic matter by heterotrophic respiration and autotrophic root respiration, generally shooted-up exponentially with temperature. It is further stated that temperature and moisture are two major driving factors affecting the soil CO$_2$ efflux of forest ecosystems (Zang and Chen 2014, Fang and Moncrieff, 2001). Guo et al. (2001) studied the organic carbon stored in paddy soils increased by 120.8-584.0 Tg in 0-100 cm soil depths due to conversion of upland soils to paddy soils in the past 600 years in China. On the other hand, the paddy soils are another important source of atmospheric CH$_4$. The N$_2$O emission does occur during the drainage period and its global warming potential (GWP) is higher in long term. Brierley and Wood (2001) proved that heterotrophic bacteria and fungi promote nitrification in acid soils of coniferous forests in Western
Europe, where bacteria Arthrobacter sp. seem to be the most highly adapted to involve heterotrophic nitrification.

Ronggui, et al. (2001) observed soil respiration and methane flux from adjacent forest, grassland and corn field by using the closed chamber method from June to November 1999. The forest soil absorbed methane at a rate range from -0.12 to -0.02 mg C m⁻² h⁻¹, while the grassland soil emitted methane at the range from undetectable levels to 0.18 mg C m⁻² h⁻¹. Linear regression analysis demonstrated that the methane flux rate was positively correlated with the soil water filled pore space and negatively correlated with gas diffusion coefficient and air filled pore spaces. The Soil respiration rate is positively correlated with the soil temperature at all there sites. Singh and Tyagi (2009) extensively described the mechanisms and related microorganisms that promote nitrification in soil, specified that the autotrophic and heterotrophic microorganisms might act as protagonists of this process. The groups of bacteria that transform the ammonium to nitrate are Nitrosomonas, Nitrosolobus, Nitrosovibrio, Nitrosopira and Nitrosococcus genus, where the overall nitrification process is controlled by ammonium and oxygen concentrations. Meenakshi et al., (2010) evaluated carbon storage versus fossil fuel substitution, a climate change mitigation option in two different land use categories based on short and long rotation forests- Sal (Shorea robustaGaertn. f.), Eucalyptus (Eucalyptus tereticornis Sm.), Poplar (Populus deltoidesMarsh), and teak (Tectona grandisL.) forests in India.

2.3 Air Pollution, Air Pollution Tolerance Index (APTI), and Anticipated Performance Index (API).

Air pollution is very much common phenomenon taking place in all over the world and the data is represented in simple terms as Air Quality Index (AQI) of that area. Pandey Kumar et al (1998) have studied the status of ambient air quality in Lucknow city, collected SO₂, NOₓ and O₃ and summarized the higher pollutants concentration in the Lucknow city due to the vehicular emission and industries. Seema Gujral et al. (2000) made an assessment of the dispersion of the ambient suspended particulate matter and the effect of meteorological parameters such as wind velocity, wind direction and temperature on dispersion at four different sites in and
around the Kota Thermal Power Station which is situated on the bank of the river Chambal in the city of Kota. Moreover, Saurabh et al (2012) assessed the Ambient Air Quality status in urban residential areas and rural residential areas of adjoining villages of Jhansi city and observed that urban residential and rural residential have highest concentration of SPM and RSPM, which were exceeded the prescribed limits of Central Pollution Control Board (CPCB), New Delhi. The average AQI value of urban residential areas (unhealthy) was found higher than the rural residential areas (moderately).

A work on seasonal and temporal variation of Ambient Air Quality Status in Raniganj-Asansol area, India was explored by Reddy and Venkataraman (2002) on SO2, NO2 and SPM from the four monitoring sites and suggested that concentrations found were greater during the winter i.e. 365.90 μg/ m3 compared with the summer (March-June) and monsoon (July-October). Mahboob Ali and Makshoof Athar (2009) measured ambient air quality monitoring in Lahore City, Pakistan and monitored pollutants like carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), particulate matter (TSP and PM10), lead (Pb), and noise level at ten different locations of the city. The sulfur dioxide, lead, and suspended particulate concentration were found very high as compared to the ambient air quality standards of USEPA and WHO guidelines. The main causes of this air pollutants present in the area due to the transportation, fossil fuels and industrial activities and road dust in the Lahor city.

Moreover, Sergey et al. (2009) observed seasonal variation of pollutant concentration of various parts of Krasnoyarsk City from 2001 to 2005 in Russia, suggested that variations in sulphur dioxide concentrations were mainly due to boiler houses, and heat stations not motor traffic and noticed that concentration of CO and NO were due to the major constituents of vehicle emissions. Asha Chelani et al (2002) have sampled air at eight hourly basis for 24 hours round the clock and twice in a week taking into account of wind speed and wind direction and found that Kolkatta is the most polluted city with regard to PM 10 followed by Mumbai, but Cochin and Chennai are relatively less polluted city. Jaya and Beena (2014) studied about seasonality of air quality assessment in the surroundings of KMML Industrial Area, Chavara in Kerala, South India. They found highest SO2 content in the winter.
season whereas the lower content was found in the summer season on the other hand, NOx content in the ambient air of study stations varied from 19.5 μg/m³ to 52.2 μg/m³ during summer season, and from 11.9 μg/m³ to 62.8 μg/m³ during winter season. They also measured concentration of free chlorine in ambient air of the almost round (60.75 μg/m³) near KMML factory. Therefore, their study revealed that the air pollution due to PM$_{10}$ and chlorine in the residential areas in the vicinity of KMML industry causes different health problems to the residents, especially in aged people and children.

The studies conducted in China (Hao et al. 2000) in which the air pollution with SO$_2$, NOx, and PM$_{10}$ were measured at selected locations of Beijing City was found that apart from vehicular emissions, coal combustion from thermal power plants were the major source of these pollutants. In another study presented by Sezer et al.(2005), showed relationship between total suspended particle and sulphur dioxide concentrations with meteorological factors for 1995–2002 for Erzurum City. They have shown that, higher TSP and SO$_2$ concentrations are strongly related to colder temperatures, lower wind speed, higher atmospheric pressure and weakly correlated with rain and high relative humidity. Jaya and Beena (2014) examined daily Air Quality Index (AQI) for the months of April – July of 2004 in the northern Mid-Atlantic region. They performed AQI stratified by county for Delaware, Maryland, New Jersey, New York, and Pennsylvania and included maxima, minima, and mean AQI values for each day. Moreover, Yan-Ju and Hui(2008) performed to assess correlation of SO$_2$ and TSP concentrations with wind speed, pressure and temperature between and relative humidity 1999 and 2003. Similarly Laxmi et al (2008) used multiple linear regression analysis to assess the relation of SO$_2$ and TSP concentrations with wind speed, pressure and temperature. Vinita Pathak (2011) carried out twenty-three plant species growing near a Beijing steel factory, an air pollution point source, found lowest APTI recorded for Wikstroemia while the highest value of APTI found Metaplexis japonica.

Assessment of air pollution tolerance index of some trees in Moradabad city, India, was carried out by Tripathi et al. in the year of 2009 to explore the relative tolerance of the plant spieces. Ten different plant species were selected from residential, commercial, and Industrial area of their city as these flora were very much
common. The quality of air with respect to SPM, SO₂ and NO₂ assessed on respective sites to investigate its effect on Biochemical parameters of the leaves i.e. pH, Total Water Content, Chlorophyll and Ascorbic acid and evaluate the air pollution tolerance index (APTI). It was concluded that *Pongamia pinnata* 15.8, *Pithecellobium dulce* 34.8, *Hollosplelea integrifolia* 55.8, and Saracca indica 52.0 having very high APTI value over control. So these were considered as high tolerant tree species. On the other hand, *Ficus rumphii* 35.7, *Azadirachta indica* 30.5, and *Grewelia robusta* 34.3, had slightly more APTI values over control so these were considered as moderately tolerant tree species, whereas *Alstonia scholaris* 21.5, *Cassia simea* 6.09 and *Bauhinia varieagata* 18.22 had less APTI values than control so they considered as sensitive species. The air pollutants SPM, SO₂, NOₓ ranged between 658.44 μg/ m³ to 159.47 μg/ m³, 119.83 μg/ m³ to 61.91 μg/ m³, and 98.41 μg/ m³ to 74.83 μg/ m³ respectively.

Joshi and Mishra,( 1998) studied the Ambient Air Quality during December 1994 to November 1995, at Jyotivihar, Orissa and during 1991 to 1995 at Indore, Madhya Pradesh, respectively. Air pollutant likes SPM, SO₂ and NOₓ were reported for the both the studies. The minimum and maximum values were 82.995 μg/m³ and 182.7 μg/m³ for SPM, 4.62 μg/m³ and 25.74 μg/m³ for SO₂ and 4.39 μg/m³ and 16.89 μg/m³ for NOₓ for Jyotivihar where concentrations of SO₂ and NOₓ were found under limits but SPM exceeding the prescribed standards for Commercial and Residential Areas.

A case study of Ambient Air Quality in an urban area and its effects on plants and human beings in Tiruchirappalli, India has been carried out by Sirajuddin et al. in 2010. They studied Suspended Particulate Matter (SPM) was the main pollutant within the Tiruchirappalli city ranged from 417.81 to 1400.49μg/m³ while SO₂ concentrations fluctuated from 10.88 to 33.70 μg/ m³ whereas NOₓ concentrations oscillated from 132.22 to 177.01μg/ m³. The concentration of SPM exceeded the ambient air quality standard of CPCB due to growing number of automobiles and poorly and congested road with heavy traffic. They found out the tolerance of various plants to air pollutants and maximum APTI was observed in *Azadirachta indica*12.95 and minimum in *Enterolobium saman*7.12 and revealed that urban air pollutants adversely affects on human health in Tiruchirappalli city while many individuals...
residing nearby traffic intersections were suffering from respiratory diseases and suggested proper environmental awareness and personal protective devices may be useful in avoiding health problems.

Alam et al., (1999) investigated the ambient air quality at road side in Dhaka City and estimated the Air Quality Index (AQI) at various locations of the city of which seventy percent were severely polluted and rest of the location were highly polluted and proposed that these conditions are very serious implications on the health of the inhabitants of the city, particularly the commuters, suffering with eye and skin irritation, headache, breathing problems etc. Meenambai and Akil, (2000) evaluated the Ambient Air Quality of Coimbatore City at ten important junctions and found that the level of SPM exceeds the ambient air quality standard of CPCB and SO$_2$ and NOx were well within the limits. The high SPM concentration might be due to traffic congestion, increased human activities and high rise buildings, existing parallel to each other. The remedial measures includes banning use of old technology vehicles, upgrading 2 stroke engines to 4 stroke engines, use of catalytic converters, planting more trees species along the road sides and proper traffic regulation.

Coglian (2001) studied meteorological variables and the index capable of identifying those variables that significantly affect the air pollution. The index was connected with attention levels of NO$_2$, CO and O$_3$ concentrations. The relation of index with some meteorological variables was analyzed by the linear multiple partial correlation statistical method. During the January–March period the correlation coefficient reaches 0.85 at Milan. Dayal and Nandini, (2000) studied the Ambient Air Quality for 10 congested areas in Bangalore City and results indicated that the SPM values in six out of 10 congested areas were above the limit, while Oxides of Nitrogen (NOx) and SO$_2$ were within the prescribed limit in all the areas. Air Quality Index (AQI) was observed that in 1 out of the 10 places, the air was clean, in 4, it could be classified as low air pollution and the remaining 5 places, was moderately polluted. Santosh and Tripathi (2008) studied that Anticipated Performance Index of some tree species considered for green belt development in and around an urban area of Varanasi city, India. They evaluated four biochemical parameters based on API for twenty seven plant species, calculated by considering their APTI values together with other socio-economic and biological parameters. Out of 27 plant species, *Ficus religiosa*, *Ficus*
infectoria, Mangifera indica showed highest API value and recommended for plantation but five species exhibited good performance.

Dulal Chandra and Pratap Kumar (2011) carried out effects of stone crushing industry on Shorea robusta and Madhuca indica foliage in Lalpahari forest and found some physical damage to leaves as a result of dust deposition, inhibition of photosynthetic activities and protein synthesis as well as susceptibility to injuries caused by microorganisms and insects. Thawale et al. (2011) carried out some biochemical changes in plant leaves as a biomarker of pollution due to anthropogenic activity and emphasized the biochemical changes occurred in four selected plant species, namely Azadirachtaindica, Mangifera indica, Delonix regia, and Cassia fistula of residential, commercial, and industrial areas of Nagpur city in India. The results of correlation indicated that the total chlorophyll and ascorbic acid is negatively correlated with SPM, SO₂, and NO₂ followed by relative water content and pH in all the plants. The leaf characteristics are positively correlated with the ambient air pollutants. Ashutosh et al. (2015) examined Air Pollution Index (APTI) of selected twenty four climber plant species to develop vertical gardens in Varanasi city which has characteristics of tall building and narrow roads. APTI values were ranging between 8.75 and 25.39, and out of 24 species but five species showed highest value of APTI (more than 25). Moreover, nineteen species showed lowest APTI values (less than 18). APTI shown high positive correlation with ascorbic acid and total chlorophyll content. However, insignificant low correlation with leaf extract pH and RWC were observed.

Tripathiet al. (2015) carried out assessment of seasonal Ambient Air Quality monitoring in year 2012 under influence of Coal Based Thermal Power Plant emission around ATPS Chachai, Madhya Pradesh and suggested highest concentrations of gaseous and particulate matter during winter could be due to low temperature and low wind speed, which lead to lower mixing height and poor dispersion. However, the lowest concentration was observed during monsoon season, might attributed to washout by rainfall and also due to high relative humidity, which reduces resuspension of dust. Singh and Rao (1980) found incidence of foliar injury symptoms to plants in the vicinity of cement factories. Alteration of leaf morphology
and anatomy as a result of air pollution were also studied by Agarwal and Agarwal (1989) and Rai et al. (2010). Verma and Singh (2006) observed distorted wax, damaged stomata and disturbances in the ornamentation of cuticles in their SEM studies on leaf surface exposed to auto pollution. Moreover, it has been reported recently that ambient air pollution from automobiles has adversely affected the plant’s chlorophyll, carotenoid, ascorbic acid, pH, relative moisture content, and the APTI (Joshi and Swami 2007). Srinivas and Purushotham (2013) carried out air pollutant concentrations PM$_{2.5}$, PM$_{10}$, sulphur dioxide (SO$_2$) and oxides of nitrogen (NOX) in industrial area at six sites of Visakhapatnam and documented high in winter in comparison with the summer or the monsoon and post monsoon seasons. The concentration of NOX ranged from 38.80 to 76.69 $\mu$g/m$^3$, whereas PM$_{10}$ was recorded from 160.96 to 178.90 $\mu$g/m$^3$ while the concentration of SO$_2$ from 78 to 69 $\mu$g/m$^3$.

Tanushree Bhattachary et al. (2012) performed to measure the air pollution status of Milk City, Anand and its impact on the prevalent vegetation in the urban habitat in the winter season and selected 10 sampling sites and measured air pollutants level with high APTI in Polyalthia longifolia (6.57-10.22), followed by Peltophorum pterocarpum (6.81-8.43) and Azadirachta indica (6.01- 7.59). Tanushree Bhattachary et al. (2013) also carried out seasonal variation in Air Pollution Tolerance Index of various plant species Azadirachta indica, Polyalthia longifolia, Ficus bengalensis, Mangifera indica, Acacia arabica and Peltophorum pterocapum of Baroda City and suggested that higher leaf relative water content in all the species documented in monsoon season. Whereas the higher average ascorbic acid concentration was encountered in winter season followed by summer but least in monsoon. The study focused on the comparative analysis of ambient air quality status in year 2012-2013 of Ahmedabad and Gandhinagar, Gujarat India by Chintan et al. (2015) suggested that during winter there was a maximum concentration range of SO$_2$ and NO$_2$ and RSPM. The minimum and maximum average concentrations of SPM were recorded from 185 $\mu$g/m$^3$ to 362 $\mu$g/m$^3$. They concluded that SO$_2$ and NO$_2$ concentrations were below the NAAQS, while RSPM concentration had shown slight more than NAAQS limits.