International Research Journal of Environment Sciences ISSN 2319–1414
Vol. **2(3),** 35-40, March **(2013)** *Int. Res. J. Environment Sci.*

A Study on Inventorization of GHGs from Energy and Industrial Sector and their Impacts in the Tungbhadra River basin, South India

M.S. Umesh Babu and E.T. Puttaiah
Department of Environmental Sciences, Kuvempu University, Shankaraghatta, Shimoga, Karnataka -577451, INDIA

Available online at: www.isca.in
Received 14th February 2013, revised 21st February 2013, accepted 10th March 2013

Abstract

The climate negotiations and treaties are clearly mentioned that stabilization of anthropogenic greenhouse gas concentrations in the atmosphere which would impact on the climate system is required. To this dialogue, IPCC has taken several initiatives to estimate and minimize the GHGs emission across the globe which will lead to the global warming. As per the IPCC and other several studies across the globe mentioned that energy and industrial sectors are the major contributor of global warming and emits GHGs largely (around 60 percent) compared to other sectors. Based on the understanding of macro level studies, we have chosen micro level study, Tungabhadra River basin in south India to understand the impacts GHGs and their level of emissions to the atmosphere. This study, focused on the energy and industrial sector in the basin to estimate the emissions of GHG by adopting a methodology, 'revised 1996 IPCC guidelines for national greenhouse gas inventory' developed by IPCC. This study found that, the ratio of emissions is increasing rapidly due to the urbanization and industrialization. The end results show that energy and industrial sector contribute almost equally but the emissions rate increasingly highly from energy sector. Thus, adopting for green energies such as solar, wind, bio gas etc., will reduce the emissions in the basin. In addition, replacing older technologies with advanced equipment will consume less energy and contribute minimum GHGs.

Keywords: IPCC, GHGs, emissions, energy, industry.

Introduction

Central to global measures to contain climate change is a reduction in emissions of Green House Gases (GHGs). Article 2 of the Kyoto Protocol of 1997 and till Doha 2012 has clearly mentioned that 'stabilization of anthropogenic greenhouse gas concentration in the atmosphere which would impact on the climate system' is required. The debate over climate change now reached an advanced stage across the globe, leading to the emergence of consensus to increase attention on climate change. The notion of climatic changes has transformed from gradual to linear, "weak signal" towards non-linear and catastrophic representations, particularly related to the possibility of abrupt or sudden climate change. Many studies indicate that the climate change is a violent and catastrophic threat. In addition rising concentrations of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from various anthropogenic activities in the atmosphere is reported. As apprehended, since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide has increased nearly 30 percent, methane concentrations have more than doubled and nitrous oxide concentrations risen by about 15 percent. Subsequently, the global mean surface temperature risen by 0.4–0.8°C[1] . As a result of this warming, 20th century's 10 warmest years have occurred in the last 15 years. Of these, 1998 was the warmest year in the record. The snow cover in the northern hemisphere has decreased, 4-8 inches of sea level rise were observed during the past century. The major global environmental problems leads to submergence of Island and also low lying areas in the world[2]. This study made an effort to estimate the GHGs at micro level i.e. at a level of River basin. It is focused on the estimation/inventory of GHGs emissions from energy and industrial sector and also documents their potential impacts on River basin within the boundary in the state of Karnataka.

Study Area: The Tungabhadra (TB) River basin is one of the major sub-basin of the Krishna river basin in peninsular India and stretches over an area of about 47,827 Sq. Km (1.45 percent of the Indian total geographical area) in the states of Karnataka (81.1 percent of the basin) and Andhra Pradesh (18.89 percent of the basin) figure 1. The total population of the TB basin is about 88.53 lakh with population density of 302 persons per Sq. Km Average literacy rate is about 64 per cent in the basin. The total forest area of the basin is about 4.48 lakh Ha in which 60 per cent of the area is situated in the upper part of the basin (Western Ghat) while the rest is spread both in middle and lower parts of the basin. Calculations are based on the secondary data obtained from the line departments.

Methodology

The methodology prescribed by the IPCC (Revised 1996) for National Greenhouse Gas Inventories is used and below said equations are adopted for estimation.

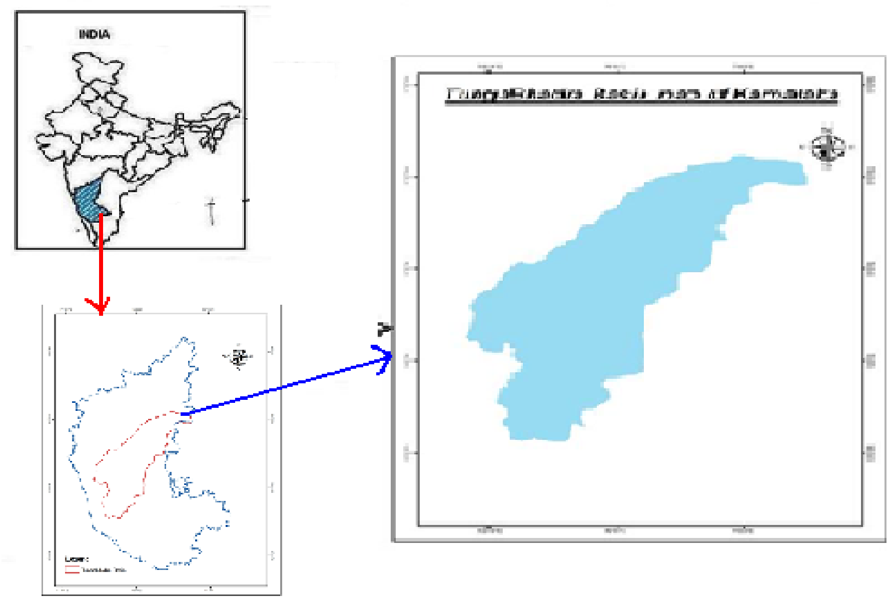

Figure-1
Location of the study area, Tungabhadra River Basin, South India

Equation 1: Fire Wood: Wood harvested for firewood, commercial timber and other uses is also estimated as significant consumption. Carbon dioxide emissions from the fuel wood is calculated through using below said equation

CO_2 E = FW_{HH} x FW_{PC} x FW_{EF}

Where, CO_2 E = Carbon dioxide Emissions in Gg, FW_{HH} = Number of households use firewood, FW_{PC} = Per capita consumption of fuelwood in tones/year, FW_{EF} = Carbon dioxide emissions factor for fuelwood burnt in kg/tones.

Equation 2: Electricity: Carbon dioxide emissions from the electricity is calculated by the below shown equation

CO_2 E = E_{Con} x E_{EF}

Where, CO_2 E = Carbon dioxide Emissions in Gg, E_{Con} = Electricity consumption from different sectors in KW, E_{EF} = Carbon dioxide Emissions Factor 0.80 kg/ KW.

Equation 3: Fossil Fuels: The IPCC methodology breaks the calculation of carbon dioxide emissions from fossil fuel combustion by the following equations in different 6 steps such as,

Step 1: Estimate Apparent Fuel Consumption in Original Units
Step 2: Convert to a Common Energy Unit
Step 3: Multiply by Emission Factors to Compute the Carbon Content
Step 4: Compute Carbon Stored
Step 5: Correct for Carbon Unoxidised
Step 6: Convert Carbon Oxidized to CO_2 Emissions in Gg

CO_2 E = F_{Con} x F_{EF} x F_{CS} x F_{CU}

Where, CO_2 E = Carbon dioxide Emissions, F_{Con} = Fuel Consumption in tones, F_{EF} = Fuel Emission Factor, F_{CS} = Fuel Carbon Stored, F_{CU} = Fuel Carbon Unoxidized.

Equation 4: Industries: The general methodology employed to estimate emissions associated with each industrial process involves the product of activity level data, e.g., amount of material produced or consumed, and an associated emission factor per unit of consumption/production according to, $Total_{ij}$ = A_j x EF_{ij}

Where, $Total_{ij}$ = the process emission (tones) of gas i from industrial sector j, A_j = the amount of activity or production of process material in industrial sector j (tones/yr), EF_{ij} = the emission factor associated with gas i per unit of activity in industrial sector j (tonne/tonne).

Results and Discussion

Scenario of Indian GHGs: India occupies 2.4 percent of the world's geographical area but supports nearly 17 percent of its population and emits less than 5 percent of GHG emissions. GHG emissions per capita in India are very low (fifth position in the world average)[3], on the other side, India, being the world's second most populous country with a burgeoning middle income population with rising energy-intensive lifestyles. It is vulnerable to climate change on several aspects, such as directly impacts on coastal districts, which are very densely populated (above 500 persons/sq.km) with over a 100 million people. Also indirectly, India is highly vulnerable to climate change as its economy is heavily reliant on climate sensitive sectors like agriculture, water etc. Though, agricultural sector contribution is only 17.2 percent in India's GDP growth[4] in 2011-2012, about 68 per cent of the country's workforce is employed in this sector. As per the regional model (HadRM2, IS92a scenario), the projections of climate variables for the

2050s, under the IS92a scenario of GHG emissions concerned the possible impacts of climate change on society and the environment[5].

Contributions of GHGs Energy Sector: Energy-related activities are the primary sources of anthropogenic greenhouse gas emissions, accounting for about 60 percent of the total emissions annually on a carbon equivalent, and contributed about 20 percent of the nation's carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions, respectively[6]. Energy related CO_2 emissions alone contributed 60 percent of national emissions from all sources on a carbon equivalent while the non-CO_2 emissions from energy represented a much smaller portion of total national emissions.

The main energy resources in the study area are grouped into two broad categories, viz. commercial (oil, natural gas, electricity); non-commercial (fuel wood). In India, over 65 per cent of the total energy consumption is met by commercial energy sources, and the remaining 35 percent comes from non-commercial and renewable sources[7]. The rate of coal consumption in the production of electricity, overall, India is of the order of 0.77–0.85 kg/kW h and on average CO_2 emissions are about 0.80kg/KWh[8]. At household level, nature and extent of energy use is directly related to the income sources, with marginal sections depending on kerosene and fuel wood. Growth in household income and urbanization has been accompanied by a change in fuels to LPG to electricity from fuel wood and kerosene. Urban home largely depends consumption of on cooking gas for its energy requirement; 85 - 90 per cent of the energy demand of a rural home is dependent on fuel wood. Solar energy is found to be limited to the water heating and lighting purposes.

GHGs Emissions from Burning of Fossil Fuels: Emissions from fossil fuel combustion comprise the vast majority of energy-related emissions and the consumption levels has been increased[9], CO_2 is the primary gas emitted. Due to the relative importance of fossil fuel combustion, CO_2 emissions are considered separately than other emissions. Fossil fuel combustion also emits CH_4 and N_2O as well as criteria pollutants such as nitrogen oxides (NO_x), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOCs). Fossil fuel combustion from stationary and mobile sources was the second largest source of N_2O emissions, and overall energy related activities are the largest sources of emissions.

The consumption of fossil fuels such as petrol, diesel, kerosene and LPG rate is increasing every year see table 1 and depends largely on the advanced technologies, the number of automobiles are rising intensely in the TB basin. An average of 33 percent growth of automobiles in the last five years is observed in the TB basin. It interns leads to excessive consumption of fossil fuels and contribute larger GHG emissions. Moreover, motor vehicles, road construction and also railways guage lines indicate an increasing trend in growth. Although it signifies development, associated initiatives to leading more emissions of GHGs see table 1.

Table-1
Carbon dioxide emissions (in Gg) from fossil fuel (Petrol, Diesel, Kerosene and LPG) combustions in TB basin

Year	Energy	Consumption in 10^3 tonnes	Conversion Factor (TJ/Unit)	Consumption (TJ)	Carbon Emission Factor (tC/Tj)	Carbon Content (tC)	Carbon Content (Gg C)	Fraction of Carbon Oxidized	Actual Carbon Emissions (Gg C)	Actual CO_2 Emissions (Gg CO_2)
		A	B	C=A*B	D	E=(C*D)	F=(E*10^{-3})	G	H=(G*F)	I=(H*44/12)
1995	Petrol + Diesel	329.3	43.3	14268.6	20.2	288226.4	288.2	1.0	285.3	1044.4
	Kerosene	141.1	44.8	6315.8	19.6	123790.3	123.8	1.0	122.6	448.5
	LPG	44.6	47.3	2107.7	17.2	36252.1	36.3	1.0	36.1	132.0
	Total	515.0		22692.1		448268.7	448.3		444.0	1624.9
2000	Petrol +Diesel	385.7	43.3	16713.6	20.2	337613.7	337.6	1.0	334.2	1223.3
	Kerosene	116.2	44.8	5201.9	19.6	101958.1	102.0	1.0	100.9	369.4
	LPG	43.3	47.3	2050.4	17.2	35266.0	35.3	1.0	35.1	128.4
	Total	545.3		23965.8		474837.9	474.8		470.3	1721.2
2005	Petrol +Diesel	458.5	43.3	19866.0	20.2	401292.8	401.3	1.0	397.3	1454.0
	Kerosene	114.9	44.8	5140.2	19.6	100748.6	100.7	1.0	99.7	365.1
	LPG	46.8	47.3	2215.1	17.2	38100.2	38.1	1.0	37.9	138.7
	Total	620.2		27221.3		540141.7	540.1		534.9	1957.8
2011	Petrol +Diesel	686.1	43.3	29727.3	20.2	600491.1	600.5	1.0	594.5	2175.8
	Kerosene	117.1	44.8	5239.3	19.6	102690.9	102.7	1.0	101.7	372.1
	LPG	53.2	47.3	2516.8	17.2	43289.7	43.3	1.0	43.1	157.6
	Total	856.3	-	37483.5	-	746471.7	746.5	-	739.2	2705.6

Data Source: Indian Oil Corporation (IOC), Bangalore, Department of Food and Civil Supplies, Bangalore

The carbon dioxide emissions shows an increasing trend in the TB basin see figure 2 due to increase in the motor vehicles and consumption of LPG. The kerosene distribution is decreasing because of limited supply and people are adopting to modern cooking methods such as LPG, biogas and solar. The carbon dioxide emissions in the year 1995 was about 1625 Gg and in the year 2011 reached upto 2706 Gg and there is a 40 percent growth in the last two decades in the TB basin see figure 2 and table 1. The unexpected growth in the energy sector leads to high contribution of GHGs and leads to global warming. Thus, mitigation strategies on fossil fuel consumption is essential and minimizing the growth would be a real approach for the current development. Moreover, focusing on adopting green energies such as solar, wind etc will reduce the contributions of GHGs in the TB basin.

Energy-related activities other than fuel combustion, such as the production, transmission storage, and distribution of fossil fuels, also emit greenhouse gases. These emissions consist primarily of CH_4 from natural gas, petroleum and coal mining. Smaller quantities of CO_2, CO, NMVOCs and NOx are also emitted. In addition, the combustion of biomass and biomass-based fuels emits greenhouse gases. Carbon dioxide emissions from these activities are not included in the national emission total under the energy sector because biomass fuels are of biogenic origin.

GHG Emissions from Burning of Fire Wood: According to National Sample Survey of 58th round, 889 and 277 households per 1000 households of rural and urban areas use wood[10] for cooking, heating etc,.The larger studies suggest that an average of 2.38 tonnes per family of 5 persons per year is required[11]. The estimation of carbon dioxide emissions in the year 2000 was 228.4 Gg and in the year 2010-11 was 241 Gg according to the 1991 and 2001 census of India. The growth rate is 5.25 per decade. The consumption as well as emissions is increasing at the minimum rate compared to other emissions.

Electricity Consumption and Emissions of GHGs: The electricity consumption is increasing rapidly due to growth in urbanization and industrialization. The household consumption as well as commercial consumption of electricity has been increasing at the rate of 30 percent for five years. The emissions of carbon dioxide from the electricity is rising every year. CO_2 emission in the year 2005 was 305 Gg and it is 514 Gg in the year 2011 and there is 41 percent growth in the last five years see figure 3. Therefore, focus on emissions reduction is required through adopting advanced technologies and machineries at the industrial level. Simultaneously, concentrations on household emissions is essential and should subsidize the household electrical equipments to reduce the GHG emissions effectively.

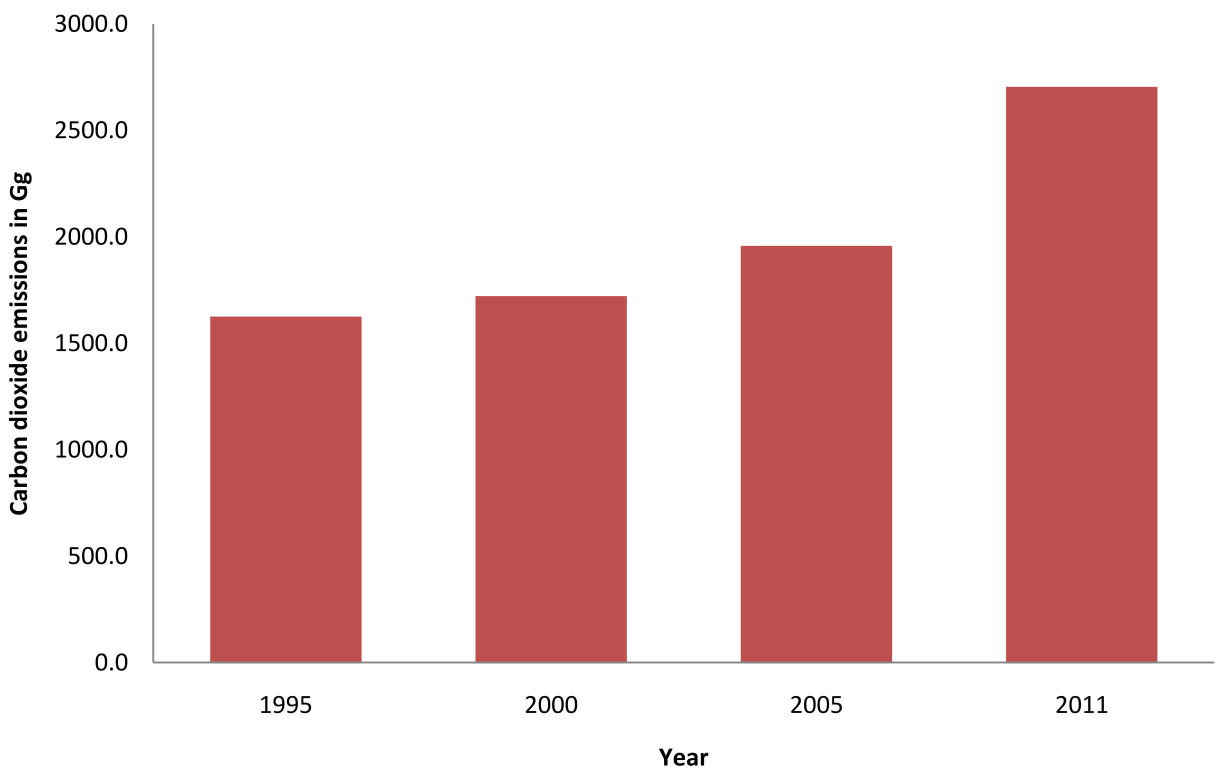

Figure-2
Carbon dioxide emissions (in Gg) from fossil fuel burning in the TB basin from 1995-2005

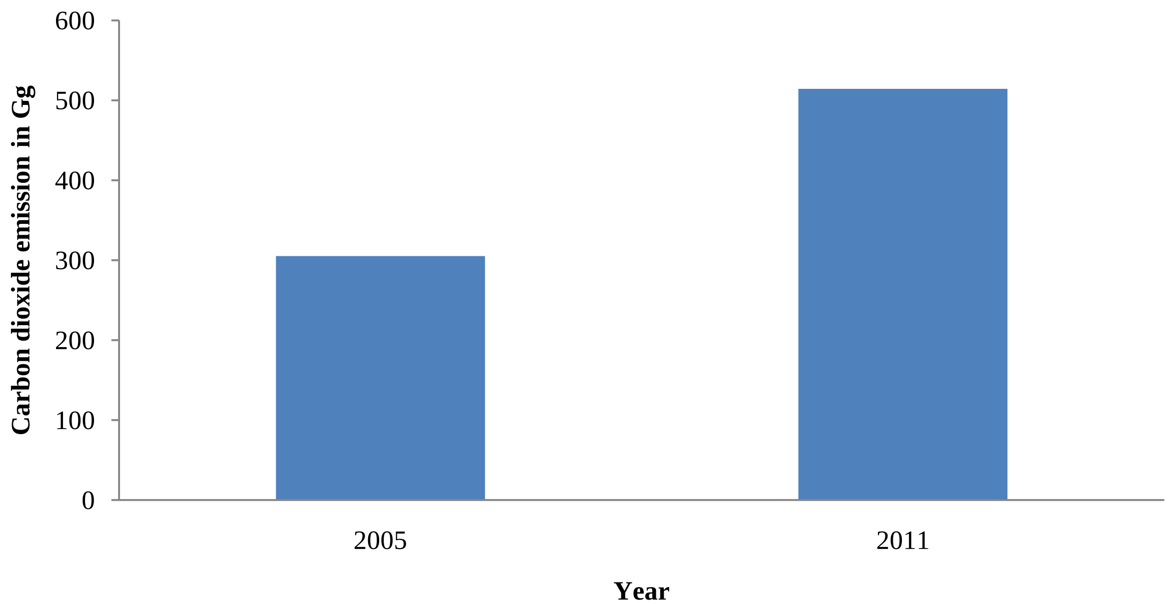

Figure-3
Carbon dioxide emissions (in Gg) from the electricity consumption through household and commercial activities in TB basin

Note: Electricity consumption in considered for the year 2005 and 2011 due to inconsistency in the availability of data

Industrial GHG Emissiosns: Greenhouse gas emissions are produced as a by-product of various non-energy related activities. The transformation often results in the release of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)[6]. The process addressed in this section includes cement production, lime manufacture, limestone and dolomite use (e.g., flux gas desulfurization, and glass manufacturing), soda ash production and use, CO_2 manufacture, iron and steel production, ammonia manufacture, Ferroalloy production, aluminium production, petrochemical production (including black carbon, ethylene, dichloroethylene, styrene, and methanol), silicon carbide production, adipic acid production, and nitric acid production.

In addition to the above other greenhouse gases such as fluorinated compounds called hydroflurocarbons (HFCs), perflurocarbons (PFCs), and sulfur hexafluoride (SF_6) emits into the atmosphere and they are called as anthropogenic greenhouse gases. The present contribution of these gases to the radiative forcing effects largely, however, their extreme long life time will continue to accumulate in the atmosphere as long as emissions continue[6].

The study area has large scale Iron and Steel and Paper and Pulp manufacturing industries across the basin. These industries emits large amounts of carbon dioxide and other GHGs while producing the products. In which CO_2 contributions from Iron and Steel industries is maximum and other gases such as NOx, NMOVC, CO and SO_2 are maximum from Paper and Pulp industries. The Iron and Steel industries emit 3423 Gg of CO_2 and it is same across the years 1995, 2000 and 2005 because the quantaum of production has not been changed over a period. The overall GHGs (except CO_2) emissions from Paper and Pulp and Iron and Steel industries in the basin is 1426.8 Gg and it reflects same across the other consecutive years due to maintaining of constant production see table 2.

Table-2
GHGs emissions (in Gg) from Paper and pulp and Iron and Steel industries in the TB basin

Variables	Pollutant Emitted in Gg
CO_2	3423
Nox	120.2
NMOC	296.6
CO	448.9
SO2	561.1
Total	4,849.80

Inventory of GHGs from Energy and Industrial Sector: The emissions from energy and industrial sectors are varied from year to year due to development in the urbanization and industrialization over a period. The emissions from energy sector is increasing drastically[12] due to increase in the motor vehicles, fossil fuel consumption for different commercial activities and also rise in the population in the TB basin. The energy sector in the year 1995 emitted 34.3 percent of GHGs and it is increased up to 50.3 percent in the year 2011 because of rapid development and enhancement in consumption of fossil fuels, electricity and firewood across the basin. Industrial sector also contributes significantly 65.7 percent in the year 1995 and it is 49.7 percent in the year 2011 but the quantity of emissions is same across the years. The industrial emission rate is decreasing compared to the energy sector because the quantum of emissions from energy sector is rising every year where as it is same in the industrial sector see table 3.

Table-3
Carbon dioxide emissions (in Gg) from energy and industrial sector in TB basin

Year	Energy		Industry*		Total
	In Gg	In %	In Gg	In %	
1995	1785.1	34.3	3423.0	65.7	5208.1
2000	1860.6	35.2	3423.0	64.8	5283.6
2005	2399.3	41.2	3423.0	58.8	5822.3
2011	3461.1	50.3	3423.0	49.7	6884.1

Note: *Industrial emissions are constant due to constant in the production of industries across the years

Conclusion

The ratio of GHG emissions from both energy and industrial sector is intensifying every year in the basin. The contribution of GHGs especially carbon dioxide from energy and industry sector is mounting and releasing GHGs to the atmosphere significantly in the basin. The energy sector contributes about 34-50 percent and the rest of the 50 percent emits from the industrial sector. The burning of fossil fuel such as petrol, diesel, LPG and Kerosene are the major contributor in the energy sector. Likewise, Iron and Steel industries are the foremost contributor of GHGs from the industrial sector. Thus, adopting various short-term and long-term measures initiated by the government for the reduction of GHG emissions from the energy sector is essential. Among them, improvement of energy efficiency through upgrading currently employed technologies secondly, introduction of advanced technologies that are more efficient or based on renewable energy sources would be ideal. There is a significant potential for the generation of power from non-conventional energy sources, and a number of technologies, which have been successfully harnessed, were solar energy, wind power, mini/micro hydel power, biomass gasification and bagasse cogeneration[13]. Because, renewable energy sector has initiated several technologies to overcome fossil fuels. The government of India has taken several measures by weeding out commercial vehicles which are more than 8-15 year old, introducing lead free petrol for vehicles and CNG vehicles, and also Bharat II standard norms for cars to bring down vehicular emissions. Similarly, industry sector should adopt strategies and techniques of Clean Development Mechanism (CDM) effectively to minimize the emissions. Replacing old machines with advanced instrument will reduce the emissions to the certain extent.

References

1. Sharma S., Bhattacharya S. and Garg A.A., Greenhouse Gas Emissions from India: A Perspective, *Current Science*, **90**, **(2006)**

2. Sugirtharan M. and Venuthasan T., Farmers awareness on climate change related issues at some irrigable areas of Batticoloa district, Srilanka, *International Research Journal of Environmental Sciences*, **1(2)**, 29-32 **(2012)**

3. Srinivasn A., Asian perspectives on climate regime beyond http://enviroscope.iges.or.jp/modules/envirolib/ upload/169/ attach/03_india.pdf **(2012)**

4. Economy of India, http://en.wikipedia.org/wiki/ Economy_of_India **(2012)**

5. Ministry of Environment and Forest (MoEF). India's Initial National Communication to the United Nations Conventions on Climate Change, http://www.undp.org/content/dam/india/docs/ **(2004)**

6. Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1999-2010 http://www.epa.gov/climatechange/Downloads/ ghgemissions/US-GHG-Inventory-2012-Chapter-3-Energy.pdf **(2012)**

7. Tenth five year plan, 2002-07, http://planningcommission.nic.in/plans/planrel/fiveyr/10th/ volume2/v2_ch7_3.pdf **(2012)**

8. Raghuvanshi S.P., Avinash Chandra, Ashok Kumar Raghav. Carbon dioxide emissions from coal based power generation in India, Elsevier Ltd, **(2005)**

9. Kiran L.D., Vivek S.M. and Dilip S.R., Impact of industrial effluent discharge on physic-chemical characteristics of agricultural soil, *International Research Journal of Environmental Sciences*, **1(3)**, 33-36 **(2012)**

10. National Sample Survey Organization. Household consumer expenditure and employment – unemployment situation in India, NSS 58th Round, Report No. 484 (58/1.0/1), **(2003)**

11. Ramachandra, Jagadeesh K., Rao G.R., Kiran M.K., Jagadish K.S., Mapping of fuelwood trees in Kolar district using remote sensing data and GIS http://wgbis.ces.iisc.ernet.in/energy/paper/fuelwood/fuelwood.html **(2012)**

12. Kumar S., Himanshu S.K. and Gupta K.K., Effect of global warming on mankind- A review, *International Research Journal of Environmental Sciences*, **1(4)**, 56-59 **(2012)**

13. Chatterjee K., An Indian Perspectives of Climate Change Mitigation: Poverty Eradication, Through Sustainable Economic Growth http://www.climatechangecentre.net/pdf/IPerspectiveCCM.pdf **(2012)**