Green House Emissions along South West Coast of India-A Neural Net Work Modeling

R.Gladis Latha[1], D.Vetha Roy[2] and R.Krishna Sharma[3]

[1]Department of Chemistry, Holy Cross College, Nagercoil, KanyaKumari District, Tamil Nadu,India.
lathagladis@gmail.com
[2]Department of Chemistry and Research Section, Scott Christian College, Nagercoil, KanyaKumari District, Tamil Nadu,India.
drvetharoy@gmail.com
[3]Department of Physics, Mepco Schlenk Engineering College, Sivakasi, Tamil Nadu,India.
krisharma555@gmail.com

ABSTRACT

Traditional method of retting has adverse impacts on the eco system and retting grounds have revealed extensive damage to the environment with the liberation of gaseous pollutants including greenhouse emissions, into the atmosphere. The paper evaluates the emission of carbondioxide and methane and their possible contribution to the greenhouse effect. Season wise variation shows that the concentration of both the gases are maximum in summer. Relative increase in percentage of Eff_{CO2} and Atm_{CO2} show that there is a definite contribution of CO_2 from the effluent to the atmosphere. A simple neural scheme is developed to forecast the future CO_2 concentrations, with temperature and wind velocity (RH) as inputs. **It is noticed that even small changes in the concentration of CH_4 leads to significant variations in the concentration of $CO_{2..}$**

Keywords : Coir Retting, Effluent, Degradation, Pollutants, Radiative Forcing, Methanogenesis, Global Warming.

1. INTRODUCTION

Continuous carbon emission into the atmosphere has emerged as a major global environmental issue and poses a threat to human life. In addition to CO_2 and CH_4, N_2O, water vapour and CFCs also contribute to green house effect[1,2].The steady rise in the annual atmospheric temperature (0.4–0.8 C) with consequent melting of glaciers accompanied by rising global mean sea levels, (1 to 2 mm. per year), signals the impact of global warming primarily due to green house gases[3].

Between1990 and 2010, global CO_2 emissions from anthropogenic sources have grown around 60%[4]. Two-thirds of these emissions are contributed by developed countries, India being the sixth largest greenhouse gas contributor to climate changes around the globe[5].Carbondioxide is emitted mainly from burning of fossil fuels as well as respiration, and decomposition of organic matter. About 57% of the emissions go to increase the atmospheric level, with much of the remainder contributing to ocean acidification[6]. Methane being the second most important greenhouse gas on a per molecular basis, it is much more effective (~22 times) than CO_2. Anthropogenic emissions of methane arise from agricultural and waste disposal, wetlands, enteric fermentation, animal and human wastes, rice paddies, biomass burning, landfills and extraction of fossil fuels[7]. These increasing concentrations have raised concern due to their potential effects on atmospheric chemistry and consequent climatic changes induced by higher levels of ozone, water vapour, the hydroxyl radical, and numerous other entities. About 90% of total emissions of methane are consumed by reaction with tropospheric hydroxyl radical, 5% by soil absorption[8] , and the remaining 5% of methane flux, averaged to 27 Tg/year enters the stratosphere[9]. Enteric fermentation sites and waste water pools are a major contributor of both CO_2 and CH_4 though under different redox conditions. The vast Indian coastal regions contribute significantly to the emission of CO_2 and CH_4 from their coconut coir retting sites, through enteric fermentation, a subject under discussion.

Methanogenesis is the final step in the decay of organic matter and there are two classes of bacteria actively involved in the methane cycle. Methanogenic bacteria generate methane by breaking down organic matter in the absence of oxygen releasing carbon dioxide and methane. Methanotrophic bacteria oxidize methane to carbon dioxide.

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4 \text{ -----(1)}$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \text{ -----(2)}$$

Free radical oxidation of methane considerably restricts the green house gas in the atmosphere though carbondioxide, and ozone are the inevitable byproducts.

$$CH_4 + OH + 9O_2 \rightarrow CO_2 + 0.5H_2 + 2H_2O + 5O_3 \text{ ----------- (3)}$$

Significant levels of CO_2 and CH_4 in any area should have an impact in the Green House Effect too. These green house gases absorb in the IR region reradiate some energy (high wave length) upward to space, which gets trapped in the atmosphere thereby raising the temperature of the earth. The balance between the absorbed solar radiation and the emitted infrared radiation determines the net radiative forcing on climate. Carbondioxide absorbs and emits infrared radiation at wavelengths 4.26 µm and 14.99 µm. The gas has unique long term effects on climate change that are largely irreversible for another one thousand years even after the emission stops. The chief absorption band for methane in the infra red region is at 7.66 µm and the radiative forcing of methane increases approximately with the square root of its concentration[10]. Numerous modeling studies reported that, methane has an atmospheric lifetime of 0.6 to 8.9 years [11,12,13,14,15].

1.1 Study Area

Retting of coconut husk for the production of fibre is widespread throughout the South West Coast of peninsular India bordering Cape Comerin, the confluence of three mighty oceans , Indian Ocean, Bay of Bengal and Arabian Sea. The study area falls between latitudes 8°2' and 8°4' N and longitudes 77°26' and 77°30' E. The experimental studies were performed for a period of two years between June 2010 and May 2012 spread over four annual seasons *viz,* south west monsoon (Jun-Aug), north east monsoon (Sept-Nov), post monsoon season (Dec-Feb) and summer (Mar-May). Representative samples were collected during each season from strategic locations falling within 40 km area from Manakudy(1), Eathamozhi (2), Rajakkamangalam (3), Ganapathipuram (4), Thickurichy (5), Manavalakurichi (6), Puthur (7), Kottilpadu (8), Colachel (9) and Thengapattinam (10), along the south west coast of India.

2. MATERIALS AND METHODS

The coir industries normally allow coconut husks to ferment in retting ponds adjoining the estuaries and allied water bodies for a minimum period of three months in previously used fermentation ponds. Retting effluent samples were collected in triplicate from earmarked locations. Two retting ponds in each station under different age group (<10years and >10years) were chosen for the collection of effluents, which were sampled into previously disinfected bottles and immediately transferred to freezers. The effluent samples were analyzed for free carbon dioxide (Eff_{CO2}) using standard procedure [16].The atmospheric carbondi oxide (Atm_{CO2}) and methane levels in the coir retting region were estimated using portable digital monitors (VS70-CO_2 and VE70-CH_4 model). The collection of samples and their analysis were continued throughout, for every three month period during these two years..

3. RESULTS AND DISCUSSION

The Eff_{CO2} values reported here are the mean of the triplicate samples collected from each location. To bridge the large variations in the two retting ponds (<10years and >10years), the average of the two values are considered for discussion. The level ranges between 170 and 308 ppm during the two year period when there is a record of continuous increase in Eff_{CO2} at every station except for the dip in concentration during monsoon and an acceleration in summer (Fig 1). The heightened bacterial activity (pH 5.5) during each summer is minimized during winter when the pH is unfavourable (7.5) to the fermentation of the husk.

The relative mean percentage increase $[(s_8-s_1)/s_1]x100$ of Eff_{CO2} varies between stations during the study period comprising 8 seasons stands at 50.45. The corresponding increase in the Atm_{CO2} is estimated to be

3.26%. This increase in Atm_{CO2} level in the study area is definitely a contribution from the effluents in the retting area as the station wise variations are very similar(Fig 2).

The Atm_{CO2} levels show a similar increase in summer with a corresponding decrease in winter. It ranges from 314 to 329 ppm between the stations, whereas the normal CO_2 level in the non-retting areas remain at 300ppm.The increase in Atm_{CO2} levels could be attributed to the high retting activity during summer. The higher rate of decomposition of organic matter like pectin, phenol, and tannin during summer months is also reflected in the higher values of Atm_{CO2} level during this period.

The Atmospheric methane levels range between 0.92 and 2.81ppm with gradual increase during summer. The corresponding CH_4 levels in the non retting areas remain under non detectable limit. The smaller values of CH_4 level are due to (hydroxyl) radical oxidation of CH_4 to CO_2 (IPCC,1996). Under aerobic condition, the CH_4 levels are extremely low mainly due to oxidation of CH_4 to CO_2 and the converse is true during summer when anaerobic condition exists (Fig 3). A plot of seasonal variation between Atm_{CO2} and CH_4 in the study area reveals the linear correlation between the two gases with R=0.7355 (Fig 4).

A simple neural scheme is developed to forecast the future CO_2 concentration with temperature and wind velocity as inputs **(**Fig 5).The future Atm_{CO2} levels are not to exceed beyond the observed levels at the present rate of enteric fermentation. The model is proved significant (Fig 6a) with R=0.5648 and further improved (Fig 6b) upon adding CH_4 as one of the inputs(R=0.8419).The histograms of both CO_2 and CH_4 are informative. The maximum distribution of (31%) was observed between 321 and 323 ppm and 50% of the samples fall within 319 ppm and 323 ppm (Fig.7a) whereas for methane, the maximum distribution is observed for concentration between 1.42 ppm and 1.62 ppm and 50 % of the data points lying between 1.05 ppm and 1.71 ppm (Fig 7b). The correlation between CO_2 and CH_4 is again found to be linear and highly significant.

4. CONCLUSION

There is a definite contribution of Eff_{CO2} to the Atm_{CO2} from the coir retting ponds, and the contribution is maximum during summer. The CH_4 levels in the study area though smaller, exert a radiative forcing in the atmosphere, as reflected in the neural net work modeling where there is a drastic increase in R value (0.5648 to 0.8419) upon adding CH_4 as one of the inputs. The predicted future CO_2 levels are well within the present reported level, at the current rate of enteric fermentation of coconut husks.

REFERENCES

[1] Houghton, J.T ., The science of climate change. Cambridge University Press, Cambridge, 1995.

[2] Bush, M.,. Ecology of a changing planet. Prentice Hall, Upper Saddle River, 1997.

[3] Church ,J.A., White, N.J., A 20th century acceleration in globalsea level rise. Geophys Res Lett33:L01602, 2006.

[4] Rafaj,P.,Amann,M., Siri,J.,Wuester,H. Changes in European greenhouse gas and air pollutant emissions 1960–2010: decomposition of determining factors. Clim. Change. In press. doi: 10.1007/s10584-013-0826-0.,2013

[5] International Anthropogenic Methane Emissions; EPA 230-R-93-010; U.S. Environmental Protection Agency: Washington. Estimates for 1990.

[6] Petty,G.W. A First Course in Atmospheric Radiation.Sundog Publishing. pp. 229–251.,2004

[7] Yang, S.S.; Liu, C.M.; Liu,Y.,L. Estimation of Methane and Nitrous Oxide Emission from Animal Production Sector in Taiwan during 1990–2000; Chemosphere, 52, 1381-1388, 2003.

[8] Intergovernmental Panel on Climate Change, 1995. In: Houghton, J.T., Meira Filho, L., Bruce, J., Lee, H., Callander, B., Haites, E., Harris, H., Maskell, K. (Eds.), Climate Change 1994. Cambridge Univ. Press, Cambridge, UK, 339 pp.

[9] Gettelman, A., Holton, J.R., Rosenlof, K.H., Mass fluxes of O_3, CH_4, N_2O and CF_2Cl_2 in the lower atmosphere calculated from observational data. J. Geophys. Res. 102, 19149–19159, 1997.

[10] .Wigley,T.M.L.,Relative contributions of different trace gases to the greenhouse effect. Clim. Monit. 16, 14–28, 1987.

[11] Osborn, T., Wigley, T., A simple model for estimating methane concentration and lifetime variations. Clim. Dyn. 9, 181– 193, 1994.

[12] Crutzen, P., Overview of tropospheric chemistry: developments during the past quarter century and a look ahead. Faraday Discuss. 100, 1 –21, 1995.

[13] Brasseur,G.,Hitchman,M.H., Stratospheric response to trace gas perturbations: changes in ozone and temperature distribution. Science 240, 634–637, 1988.

[14] Lelieveld, J., Crutzen, P., Dentener, F., Changing concentration, life time and climate forcing of atmospheric methane. Tellus50B, 128– 150, 1998.

[15] Wang, Y., Jacob, D.J., Anthropogenic forcing on tropospheric ozone and OH since preindustrial times. J. Geophys. Res. 103, 31123– 31135,1998.

[16] APHA, Standard methods for the Examination of Water and Waste Water. American public Health Association. 21st Edition , 2005.

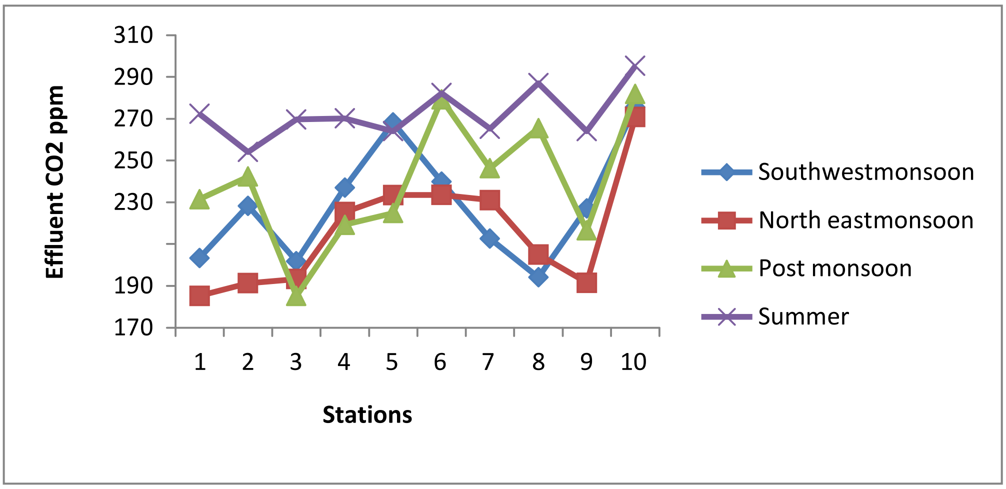

Fig:1 Quarterly variation of Effluent CO_2

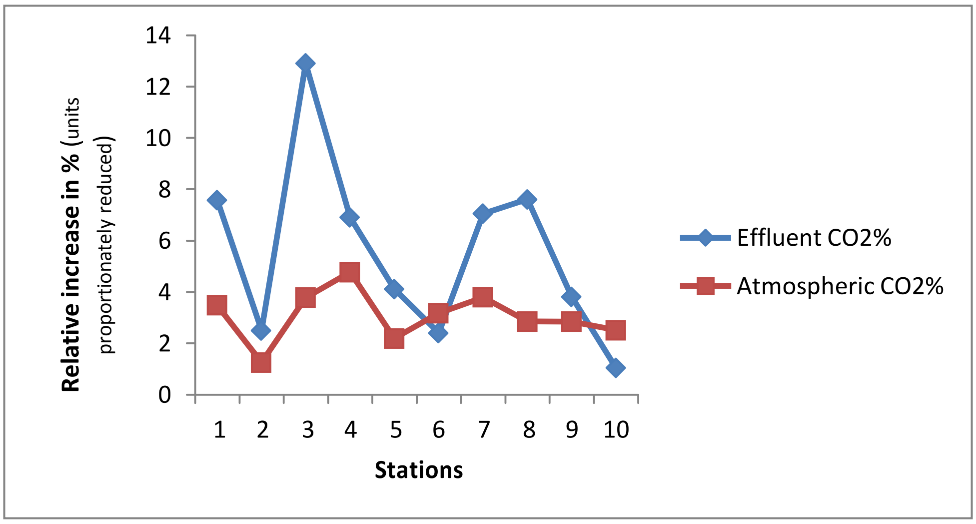

Fig:2 Variation of Effluent CO_2 Vs Atmospheric CO_2

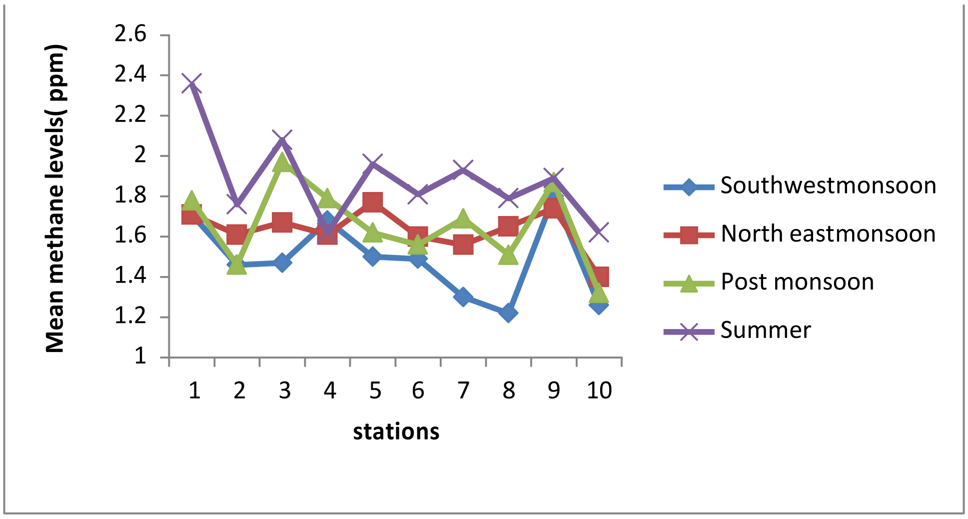

Fig: 3 Seasonal variation of CH_4

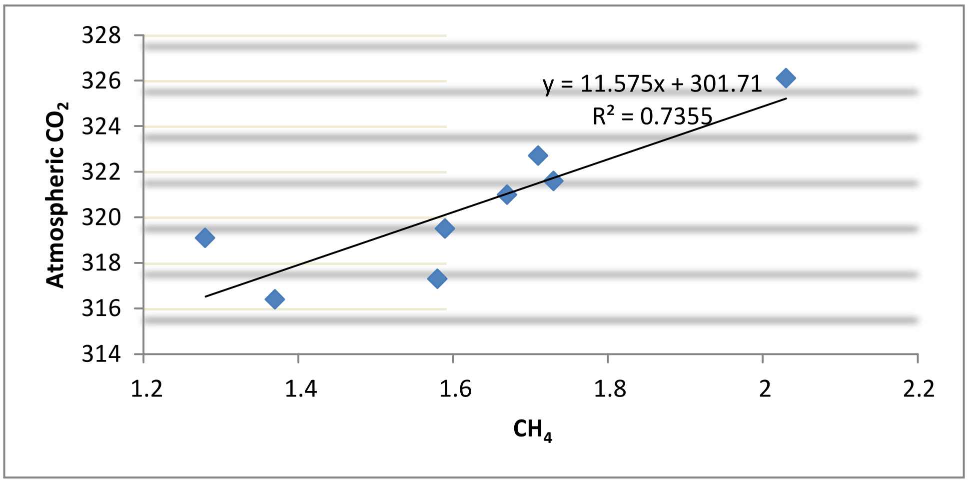

Fig: 4 Seasonal Variation of Atmospheric CO_2Vs CH_4 in the study area

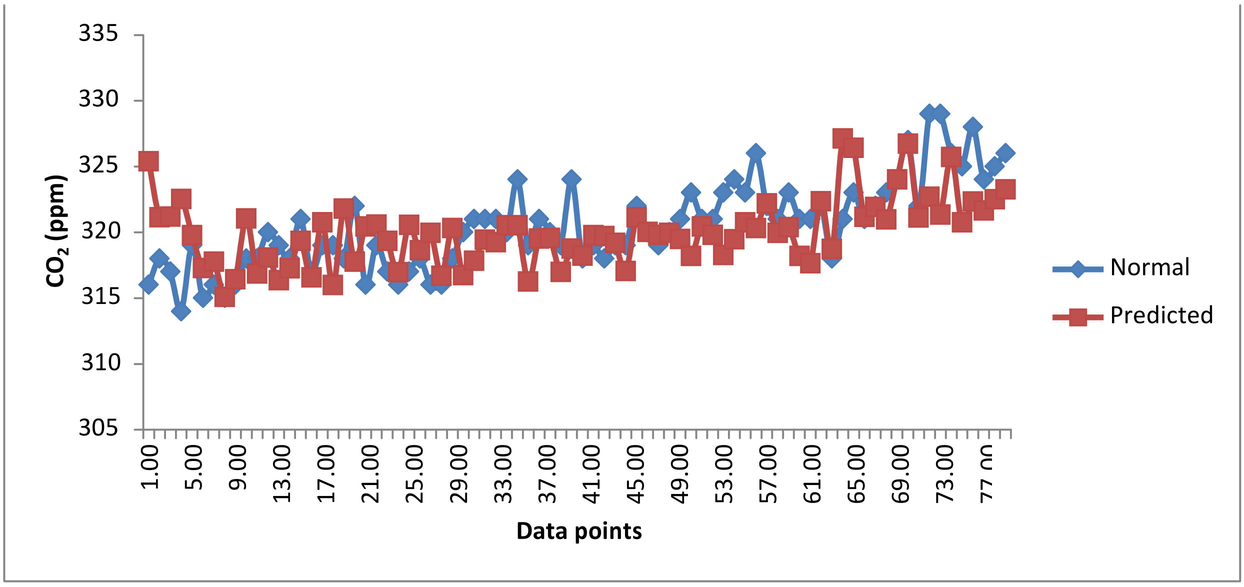

Fig:5 Normal and predicted concentrations of Atmospheric CO_2 by using

neural net work model

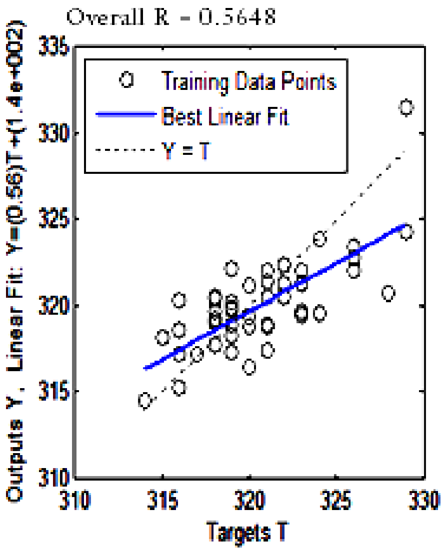

Fig:6a Linear plot of Atmospheric CO_2

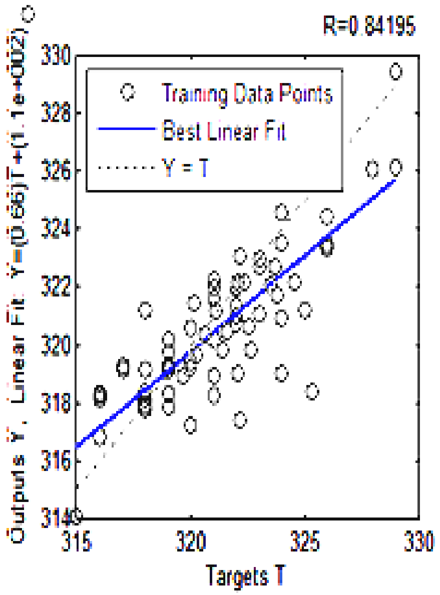

Fig:6b Linear plot of Atmospheric CO_2 with CH_4 as input.

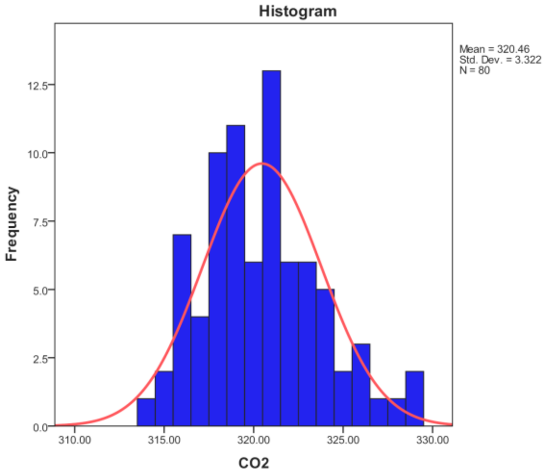

Fig-7a Frequency distribution of CO_2

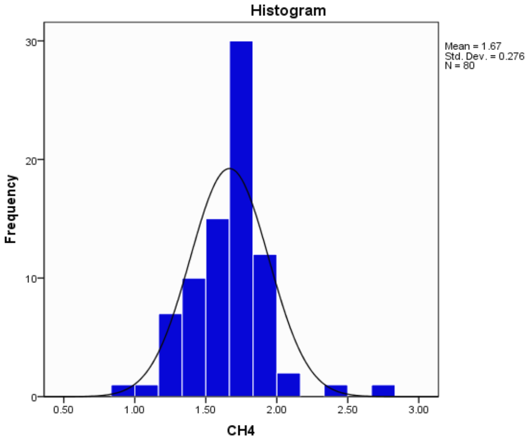

Fig-7b Frequency distribution of CH_4