International Journal of Advance Research In Science And Engineering http://www.ijarse.com
IJARSE, Vol. No.3, Special Issue (01), September 2014 ISSN-2319-8354(E)

# METHANE EMISSIONS FROM RICE CROPPING SYSTEM IN INDO-GANGETIC AREA AND STRATEGIES FOR CLIMATE CHANGE AND CLIMATE VARIABILITY

**Prabhat Kumar[1], N.C.Gupta[2], Barsha Dutta[3]**

*[1,2,3]University School of Environmental Science*
*Guru Gobind Singh Indraprastha University, Dwarka, New Delhi-110078, (India)*

## ABSTRACT

*In India, climate change impacts and climate variability have been an important concern for sustainable agriculture because of food security. This study reviews the actual monitored emission of* $CH_4$ *from rice fields of Indo-Gangetic Plain (IGP) to understand the quantitative contribution of* $CH_4$ *in greenhouse effect which significantly contributes to climate change. The study also goes through the various adaptation strategies and mitigation measures that have been adopted to reduce the* $CH_4$ *emissions from IGP. The field experiments were carried out in Chachula village, District Gautam Budha Nagar, Uttar Pradesh and in Rasalpur village, Gaya District of Bihar between July-October 2013. The soil properties were studied using redo potential meter, pH meter, soil thermometer and soil moisture meter. For the greenhouse gas estimation in Chachula village fields were treated with the application of different fertilizers combination of urea and NPK. In Gaya location of Bihar the fields were treated with same amount of urea and the observations were taken twice a day. It is concluded the the methane flux in Chachula village (U.P) varied from 0.3 to 1.0 mg*$CH_4$*/day and methane flux in Rasalpur, Gaya (Bihar) varied from 1.0 to 3.0 mg*$CH_4$*/day.*

***Keywords:*** *Adaptation Strategies, Intermittent Irrigation, Methane Emission, Rice Cropping System*

## I.INTRODUCTION

Climate change with an increase in 2-4°C will lead to yield reduction in rice which is one of the most staple food crops of India. Rice cultivation on wetland rice fields is thought to be responsible for 1.5% of the total anthropogenic methane emissions. There are three understood processes that regulate the transfer of methane from soil to the atmosphere: vascular transport, ebullition and diffusion. Climatic changes can worsen or improve these stresses significantly depending on the direction and magnitude of changes to climate in variables of relevance to crop growth factors, and also as a consequence of the impacts of secondary factors such as flood and heat-wave damages to the crops [1]. According to the estimates agriculture contributes to 20% of the global warming. Agricultural soils and wetland rice field systems are estimated to contribute about 60Tg of $CH_4$ per year. Also most of the methane emission accounted is from the rice fields (91%). The rest comes from animal husbandry (7%) and burning of agricultural wastes (2%). IGP is extensive region which occupies about 13.5 million ha of the most productive lands of India and rice is staple crop which is cultivated in IGP. The major crops of IGP are rice, wheat, pearl millet, maize and sugarcane which are cultivated in the form of dual cropping systems, the ‘rabi’ (spring harvest) and ‘kharif’ (autumn harvest) seasons [2]. According to the Intergovernmental Panel on Climate Change (IPCC), adaptation means adjustments to current or expected climate variability and changing average climate conditions, which can serve to moderate harm and exploit beneficial opportunities [3].The IGP consists of low elevation and gently sloping middle and lower reaches of the Indus and Ganges river basins which are critical for agricultural production and food security in the South Asia region. The IGP is considered as the “bread basket” of South Asia and provides food and livelihood security for hundreds of millions of its inhabitants [4]. Agriculture in the IGP will be adversely affected by an overall increase or decrease in rainfall and temperature at different growth stages of crops [5]. The mechanism behind this mitigation option is the competition between methane producing bacteria (methanogens) and sulfate reducing bacteria (SRB) for the same substrate. In the presence of sulfate, SRB are stronger competitors than methanogens leading to a reduced production of methane in the rice soil system [6]. Also switching from long duration crop varieties to short duration varieties of rice cultivars like Sakha 102 and methane emission is decreased by 25% [7]. Studies [8] showed that intermittent irrigation reduced methane emissions by 36% compared to flooding. The incorporation of well-decomposed rice straw (rice straw compost) before transplanting also reduced methane emissions by 49%. In addition, the incorporation of fresh rice straw three months before transplanting reduced methane emissions by 23%.[9] –[10] suggested that application of nitrification inhibitors have considerable influence on $CH_4$ emission in soil. Nitrification inhibitors [11]-[12] like dicyandiamide (DCD), nitrapyrin (NP), acetylene, 2-amino-4-chloro-6-methyl-peyrimidine (AM), 2-sulfanilamide-thiazole (ST), 4-amino 1, 2,4-triazole (ATC) and 3,4-dimethylpyrazole phosphate (DMPP) have been found to reduce $CH_4$ emissions significantly.

## II. MATERIALS AND METHODS

### 2.1 Cultivation area

Field experiments throughout the season were conducted in paddy fields of Chachula village (Gautam Budhnagar) western, UP and Rasalpur village (Gaya), Bihar of Indo-Gangetic-region of India. The sites are located in the Indo-Gangetic 28°21′N and 77°35′ E , 24°51’ N 85°00’ E with the altitude of 191m and 214 m respectively above mean sea level. The climate of the region is subtropical; semi-arid with the mean maximum and minimum temperatures from July to October (rice season) are between 34 and $17^0$C. Rice (Oryza sativa), varieties Sughand-1121 and PR– 14 were cultivated in the field. Rice was transplanted in flooded field after 30 days old seedling. Irrigation in rice fields was carried out at intervals of 3-5 days and subsequently the field experiments were conducted.

### 2.2 Collection and analysis of gaseous samples

Gaseous samples were drawn with 50-ml syringe with the help of a hypodermic needle (24 gauge) and Gases emission rates were determined at 0, 30, 60 min time interval by measuring the changes of methane concentrations in the fabricated acrylic chamber. $CH_4$ in the gas samples was estimated using a Gas Chromatograph fitted with a flame ionization detector (FID) with Porapak N). SS (2M) Column and Carrier gas hydrogen, nitrogen/argon and air with standard using for $CH_4$ 5ppm. Carrier gas was $N_2$ with a maintained flow rate of 14 ml min$^{-1}$. The FID detects the substances that produce ions when heated in $H_2$-air flame. The detector is insensitive to permanent gases, water and inorganic ions which do not ionize at 2100°C.

## III. RESULTS AND DISCUSSION

### 3.1 Soil characteristics

Chachula: The soil of the experiment site was silty, clayey and sandy loam in texture

**Table 1- Physico-chemical properties of soil of chachula village of U.P**

| Soil characteristics | Value |
|---|---|
| Clay (%) | 30.08 |
| Sand (%) | 29.92 |
| Silt (%) | 40 |
| Available nitrogen (kg/ha$^{-1}$) | 295 |
| pH | 5.2-6.8 |
| S.O.C (%) | 0.56 |

Rasalpur: The soil of the experiment site was silty, clayey and sandy loam in texture

**Table 2- Physico-chemical properties of soil of rasalpur village of Bihar**

| Soil characteristics | Value |
|---|---|
| Soil texture | Loam |
| Available nitrogen (kg/ha$^{-1}$) | 289 |
| pH | 6-7 |
| S.O.C (%) | 0.64 |

### 3.2 Methane Flux in Chachula village of UP

The fields were employed with 4 treatments, twice with urea in different composition and twice with urea and NPK in different composition. 50 kg of urea was applied. NPK was applied with 12% of N, 16% of P and 23% of K. The methane emissions were found to be influenced by the application of Urea and NPK in the fields.

**Table 3- Methane fluxes with different treatments at Chachula location**

| **Crop** | **Date of Sampling** | **Flux (mg$CH_4$/day)** | | | |
|---|---|---|---|---|---|
| | | **Treatment 1 Field 1 Chamber 1 (Urea)** | **Treatment 2 Field 2 Chamber 2 (Urea+NPK)** | **Treatment 3 Field 3 Chamber 3 (Urea)** | **Treatment 4 Field 4 Chamber 4 (Urea+NPK)** |
| Rice | 08/8/2013 | 0.661068 | 0.951054 | 1.047764 | 0.954977 |
| | 08/16/2013 | 0.605282 | 0.621046 | 0.719473 | 0.609264 |
| | 08/24/2013 | 0.736594 | 0.796071 | 0.617641 | 0.475812 |
| | 09/01/2013 | 0.947954 | 1.011717 | 1.343288 | 1.334787 |
| | 09/15/2013 | 0.564966 | 0.643798 | 0.674455 | 0.770806 |
| | 09/25/2013 | 0.594712 | 0.430737 | 0.348164 | 0.516749 |
| | 10/4/2013 | 0.653592 | 0.744466 | 0.650097 | 0.870291 |
| | 10/12/2013 | 0.610216 | 0.59951 | 0.626274 | 0.535277 |
| | 10/22/2013 | 0.412265 | 0.407992 | 0.479617 | 0.476237 |

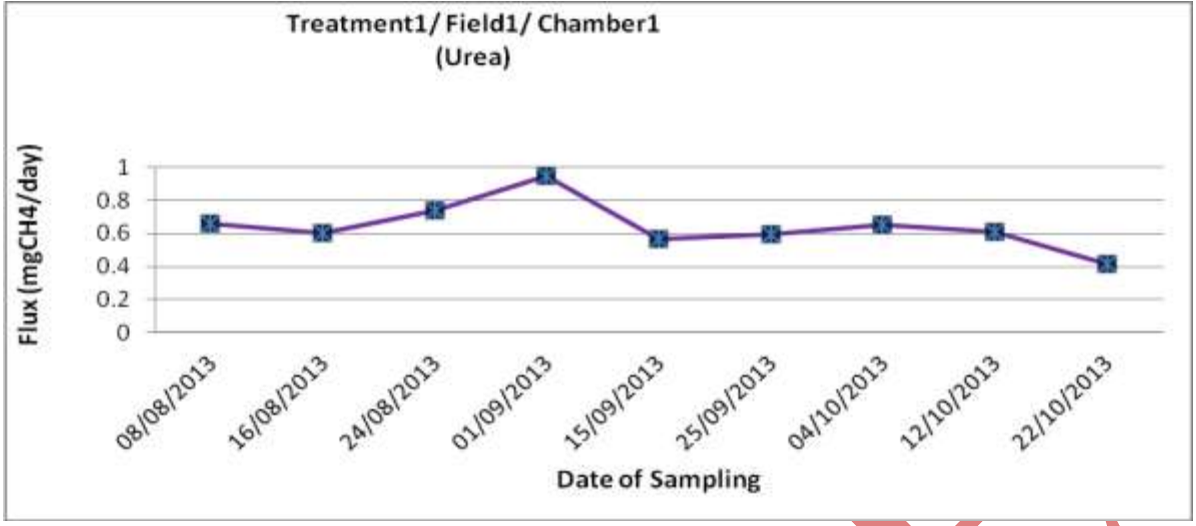

Fig. 1- Methane flux of field treated with urea

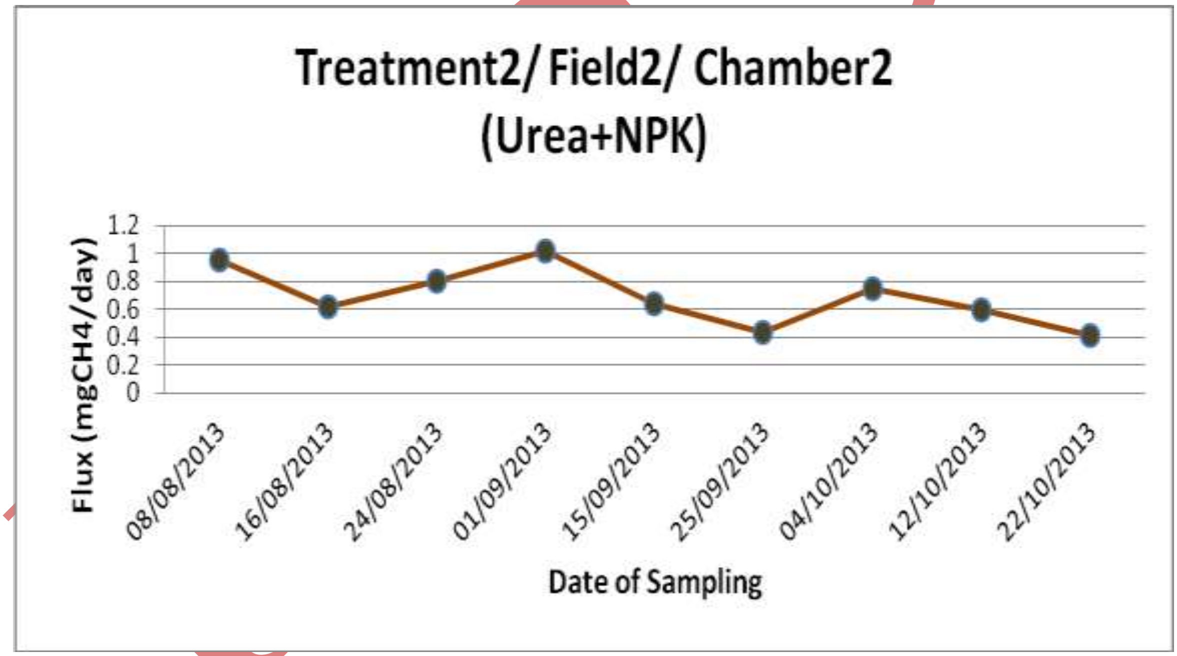

Fig. 2- Methane flux of field treated with urea and N.P.K

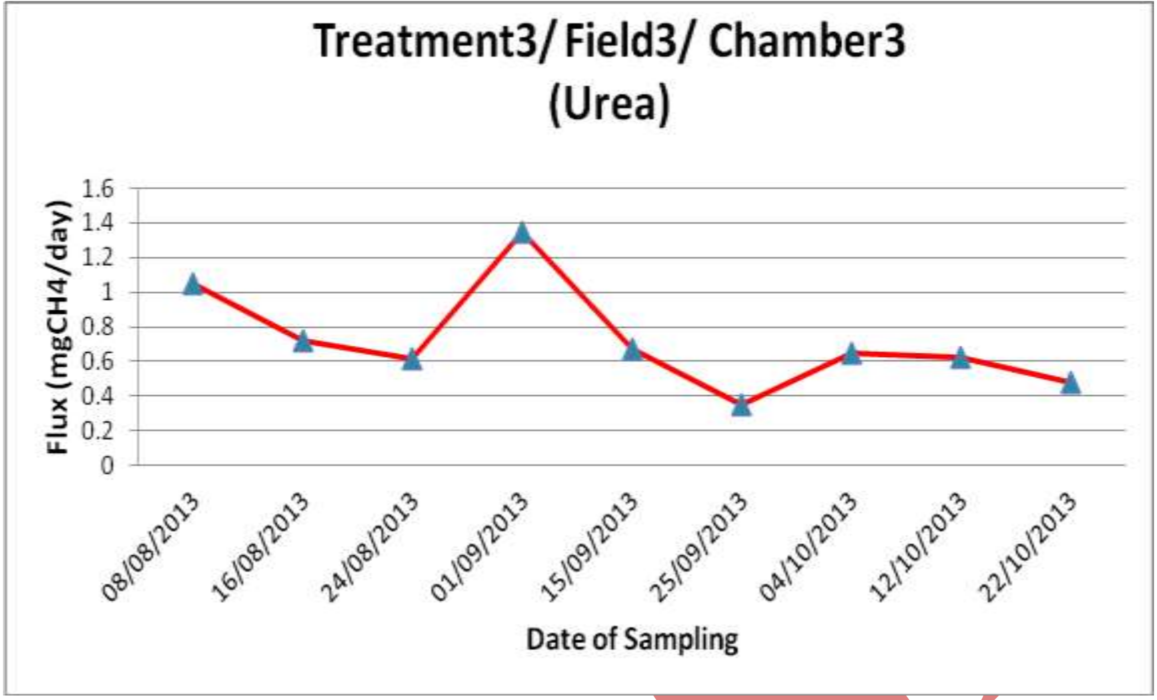

Fig. 3- Methane Flux of field treated with urea

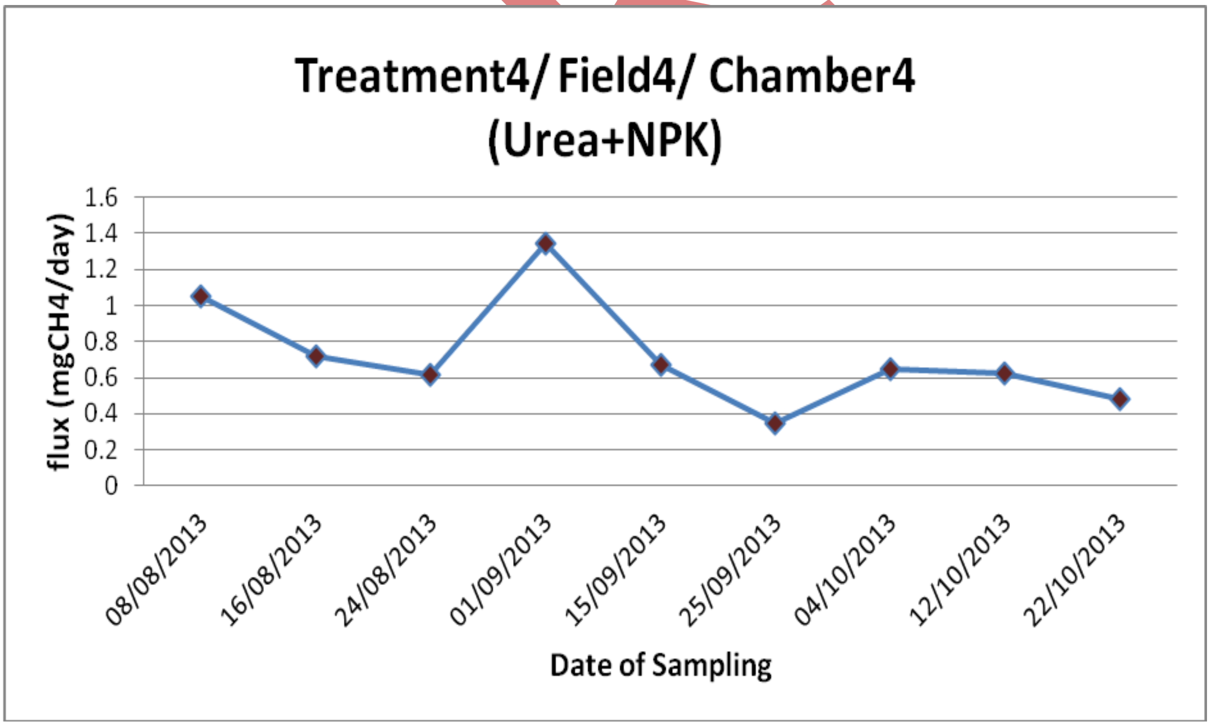

Fig. 4- Methane flux of field treated with urea and N.P.K

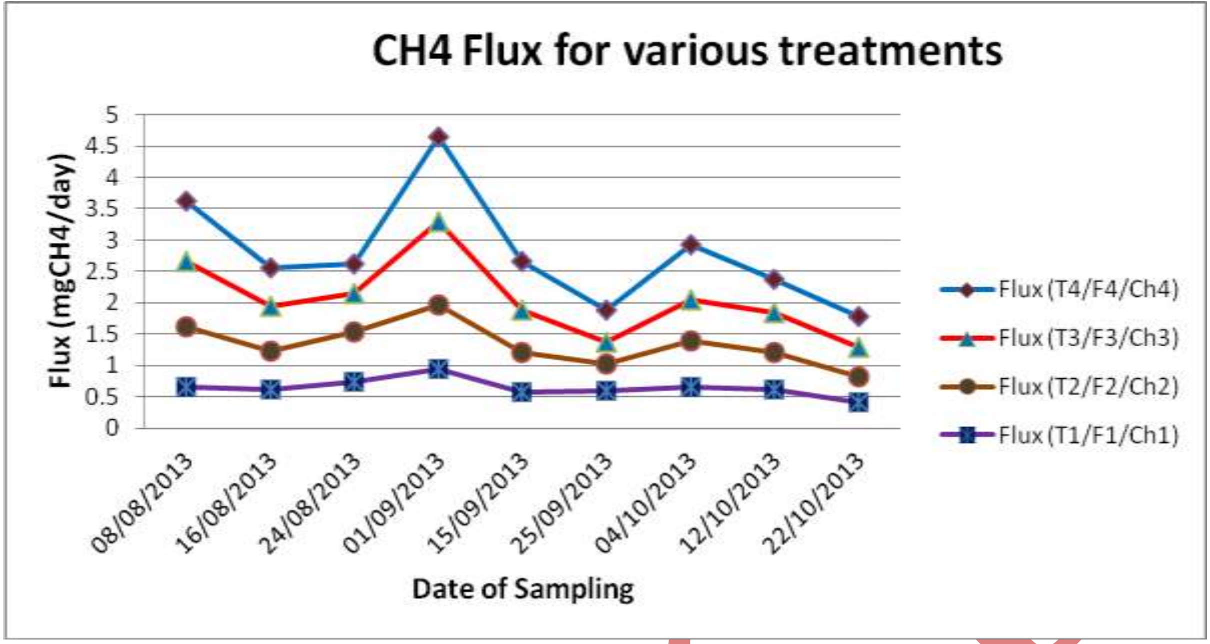

**Fig. 5- Comparing methane flux for various field treatments**

All the treatments employed show a gradual increase in methane flux in the month of August. Methane emissions are found to be highest during the month of September. It is observed that by the end of the month of October the methane flux decreases. For the first treatment the methane flux were found to vary from 0.4 to 0.9 mg $CH_4$/day. In the second treatment the methane flux varied from 0.4 to 1.0 mg $CH_4$/day and during the third treatment the methane flux varied from 0.3 to 1.3 mg $CH_4$/day. In the fourth treatment the methane flux varied from 0.4 to 1.3 mg $CH_4$/day. It has been found that all the treatments have exhibited a specific pattern of methane emission from the rice fields. The emissions went low because of intermittent drying of the soil which made the soil aerobic. The soil moisture went below the saturation during the crop growth and thus anaerobic condition required for the formation of $CH_4$ in soil did not exist.

### 3.3 Methane Flux in Rasalpur Village Gaya, Bihar

The field was treated with Urea (50 kg) and the chambers were placed twice a day for the monitoring of gasses from the rice fields. One observation was taken in the morning and another one in the evening hours.

**Table 5- Methane fluxes with different treatments at Rasalpur location**

| **Crop** | **Date of Sampling** | **Flux (mg$CH_4$/day)** | |
|---|---|---|---|
| | | **Treatment 1 Chamber 1** | **Treatment 2 Chamber 2** |
| Rice | 27/07/2013 | 2.690 | 3.094 |
| | 11/08/2013 | 3.115 | 3.369 |
| | 26/08/2013 | 2.981 | 3.114 |
| | 10/09/2013 | 3.185 | 3.364 |

| | | | |
|---|---|---|---|
| | 25/09/2013 | 3.801 | 3.398 |
| | 15/10/2013 | 1.980 | 1.561 |

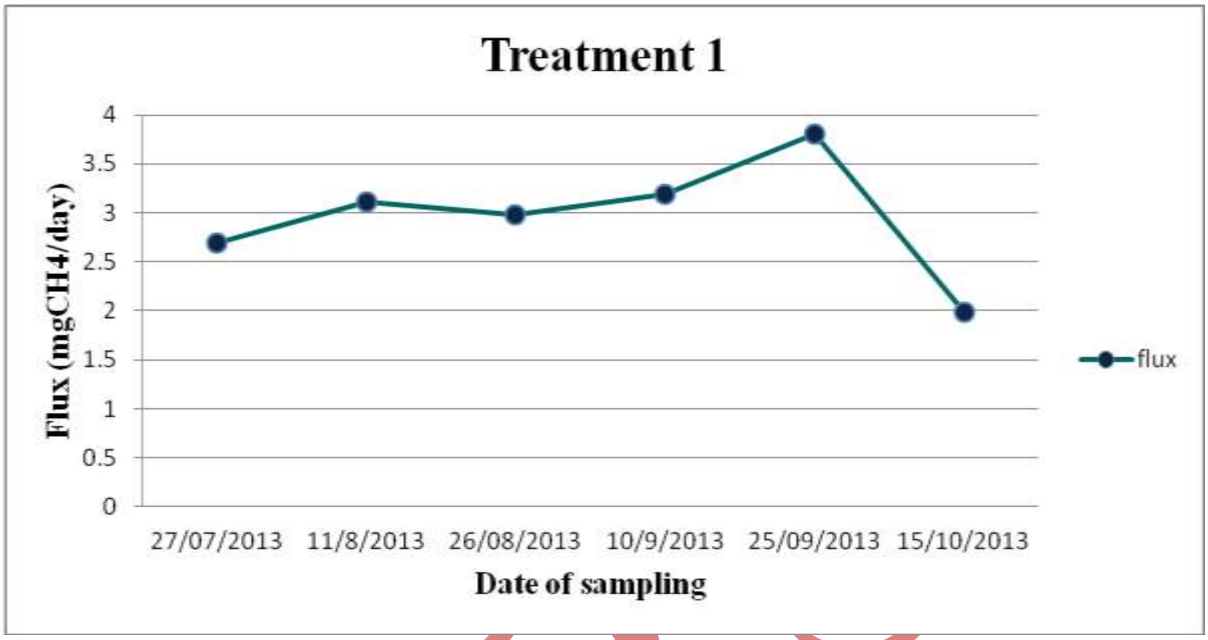

Fig. 6- Methane flux for treatment 1

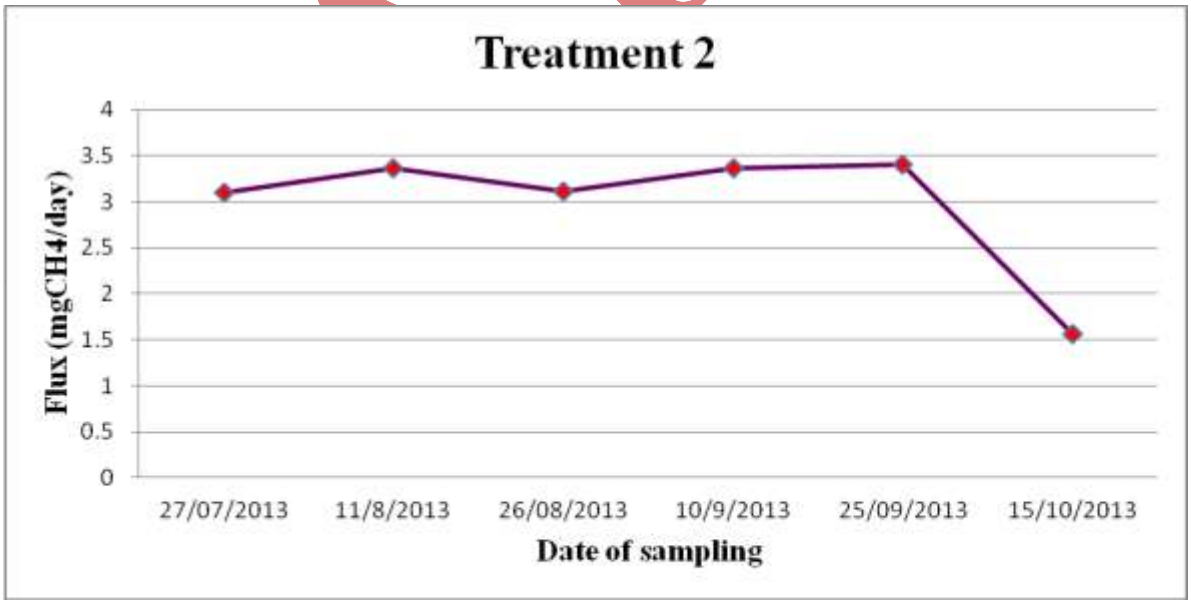

Fig. 7- Methane flux for treatment 2

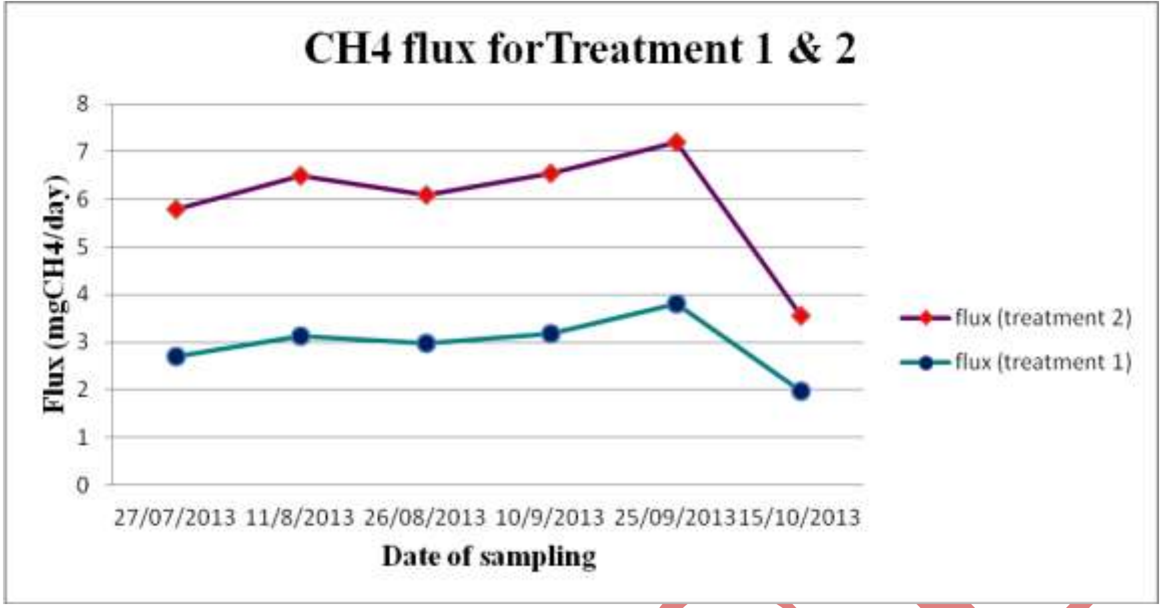

Fig. 8- Comparison of methane flux treatments

The methane emission patterns during morning and evening have shown a similar pattern. Methane emissions were slowly increasing during the season and were found highest during the month of September and then the methane flux again decreases. The emissions were found to be decreasing and went low because of intermittent drying of the soil which made the soil aerobic in nature. The soil moisture went below the saturation level during the crop growth and thus anaerobic condition required for the formation of $CH_4$ in soil did not exist during the growth. The samplings from the fields were carried out from the month of July to end of October 2013.

## IV.CONCLUSIONS

The selected locations for the study were taken from Chachula of district Gautam Budha Nagar, U.P and Rasalpur, Gaya district of Bihar. In Chachula location of UP, experiments were done using four treatments two with Urea and two with Urea and NPK. In Gaya location of Bihar the experiments were carried out using the same amount of urea and the readings were taken twice a day. Rice seedlings were transplanted in puddle and submerged soils. The alluvial soil in the region of western Uttar Pradesh and Bihar is sandy loam in texture and registered a high percolation rate. The alluvial soils require frequent irrigation for rice cultivation and soil moisture content goes below the saturation level many a times thereby rendering the soil aerobic. This is the reason of low methane emission after attaining a peak in all the treatments and in the end as the soil became dry and aerobic a decrease in $CH_4$ emission is observed. The cycle of aerobic and anaerobic condition has an influence on the emission of $CH_4$. This $CH_4$ emitted from rice cropping systems ultimately goes into the atmosphere and adds to the greenhouse effect that leads to climate change. Potential adaptation strategies should include some changes in agriculture production practices which can reduce the necessity for soil disturbances. Shift from traditional to high yielding variety (HYV) is one such option. Developing stress tolerant cultivars of rice like Sahbhagi (drought tolerant), from our data can also reduce emission substantially. It has also been observed that intermittent irrigation reduces the emission of $CH_4$ gas from rice fields as this practice dries up the soil and eliminates the anaerobic conditions required for $CH_4$ emission. Other proposed mitigation strategies include midseason aeration by short-term drainage, change in tillage practices, fertilizer management which involves switching N fertilizer from urea to ammonium sulfate. These strategies can reduce $CH_4$ emissions amounting to 25-70%. Also using cheap and readily available nitrification inhibitors like Neem cake, Neem oil and calcium carbide can reduce $CH_4$ emission significantly.

## V. ACKNOWLEDGEMENTS

The authors are grateful to the University Grant Commission, Government of India for funding the study in form of research project.

## REFERENCES

[1] New, Mark, Rahiz, Muhammad & Jagadishwor, Karmacharya, Climate change in indo gangetic agriculture recent trends, current projections, prop-climate suitability and prospects for improved climate model information, Climate Change Agriculture and Food Security Report 2012.

[2] V.K. Bansal, Koshal & A.K., Pest detection in cropping systems of the indo-gangetic plains through remote sensing, Geospatial world 2008.

[3] [IPCC] Intergovernmental Panel on Climate Change, Summary for Policymakers. In: Solomon, Climate Change and The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2007.

[4] P.K. Aggarwal, Joshi, P.K., Ingram, J.S.I., and R.K.Gupta, Adapting food systems of the indo-gangetic plains to global environmental change: key information needs to improve policy formulation. Environmental Science & Policy 7 (2004). p. 487-498.

[5] H.Pathak, P.K.Aggarwal, S.D.Singh, Climate change impact, adaptation and mitigation in agriculture, Methodology for Assessment and Application. Division of Environmental Sciences Indian Agricultural Research Institute 2012.

[6] Van Der Gon, A Hugo, Denier, Bodegom, M. Van Peter, Wassmann, Reiner, Lantin, Rhoda, Merta-Corton, M.Teodula, Sulfate-containing amendments to reduce methane emissions from rice fields: mechanisms, effectiveness and costs. Mitigation and Adaptation Strategies for Global Change. 6, 2001 p.71-89.

[7] Hasan, Eman, Proposing mitigation strategies for reducing the impact of rice cultivation on climate change in Egypt. Science Direct Water Science 27 (2014): p.69-77.

[8] Shin, Yong Kwang, Yum, Seong-Ho, Park, Moo-Eon & Lee, Byong-Lyol, 1996. Mitigation options for methane emission from rice fields in Korea. Ambio, Vol. 25, Number 4: p.289-291.

[9] H.Pathak, A.Bhatia, S. Prasad, V. Sharma, Soil and greenhouse Effect Monitoring and mitigation Division of Environmental Sciences Indian Agricultural Research Institute 2003.

[10] H.Pathak, G.Malla, A.Bhatia, Prasad, S. Jain, N. Singh, Mitigation of nitrous oxide and methane emissions from rice-wheat system of the Indo-Gangetic Plain. Chemosphere, Jan 58(2)2005: p.141-7.

[11] Smit, Barry, Skinner, W. Mark, Adaptation options in agriculture to climate change: a typology. Mitigation and Adaptation Strategies for Global Change 7: 2002p. 85-114.

[12] Prabhat K.Gupta, Vandana.Gupta, C.Sharma, Das, S. N., Purkait, N, T. K.Adhya, H.Pathak. Ramesh, K.K .Baruah , Venkatratnam, Singh, Gulab,C.S.P, Development of methane emission factors for Indian paddy fields and estimation .of national methane budget. Chemosphere 2008.