Sweet air flux in Indian Savanna

Dr. Parag Dalal
Asst. Prof. Ujjain Engineering College, Ujjain Mail – paragdalal@rediffmail.com

Abstract –
Sweet air (N_2O) is been measured every two weeks from a grassland under the coverage formed by anthropogenic activity using the closed chamber technique. Different parameters of soil as inorganic nitrogen, total nitrogen, organic nitrogen, soil pH, soil water contents etc was measured.

On other hand the nitrogen mineralization capacity of the soil is measured which is responsible for controlling the sweet air flux. These are measured by in-vitro incubation to study the effects of these factors on sweet air. The annual mean of sweet air emissions were 3.81Kg/Hact/Yr with a high emission rates in rainy season (1.76 Kg/Hact/Yr) than the summer season (1.09 Kg/Hact/Yr) and the least in winter(0.96 Kg/Hact/Yr). the sampling technique also measures other parameters as NO3- nitrogen, NH4+ nitrogen, NO2 nitrogen, and other soil variables which are not been co-related.

Key-Words –
Nitrogen, sweet air, flux, mineralization, in-vitro incubation, seasons, soil, closed chamber technique.

Introduction –
The sweet air is the another name of N_2O it is a long living trace gas with potent green house properties and natural species act as catalyst and reactant on the destruction of stratospheric ozone layer(Crutzen, 1979). On molar basis N_2O is about 250 times more effective as an absorber of inferred radiation than CO2 with atmospheric life of about 150 years (Robertson, 1993). As with many greenhouse gases the atmospheric concentration of N_2O has increased by 46 ppb(16%) since 1750 and reach up to 316 ppb in year 2000 (IPCC, 2001). The rate of increase for atmospheric N_2O has been quite variable, but on average it has been 0.75ppbv per year (Dentener and Raes, 2002). According to an estimate (Crutzen and Ehhalt, 1977) doubling the concentration of N_2O in the atmosphere would cause 10% decrease in the stratospheric ozone layer which would results in a 20% increase in the amount of ultraviolet radiation which reaches the earth surface. According to Davidson (1991) the global budget of source and sinks of atmospheric N_2O is badly out of balance. Due to seasonal and spatial variation in N_2O emission from natural ecosystems are difficult to quantify (Smith *et al.*, 1994; Dobbie & Smith 2001).

Materials and methods –

This study is carried in a site selected in Ujjain Engineering College, Ujjain external campus were the

grazing is uncontrolled throughout the year. The grassland is been affected by seasonal changes as its most lively in rainy season and about dry in summer. For the whole year the savanna is been covered by different species of grass, in addition to it in the rainy season the soil surface is turned green and in hot and cold seasons the graminoids become dormant.

The main irrigation source still in 21st century is annual rainfall (SW and NE Mansoon) which is about 960 mm in 2014. The climate is tropical type with a maximum temperature of 48°c and minimum of 4°C. The annual rainfall data of Ujjain Tehsil from 2000 to 2010 is –

Table 1: Rainfall Measurements of Last Decade –

Year	June	July	August	September	October	November	December	January	February	March	April	May	Total	Average
2001	270.8	255.25	48.4	179	0	8.4	6.8	0	0	0	0	0	768.7	64.05
2002	102.8	553.2	245.4	6	0	2.4	0	0	0	0	0	0	909.8	75.82
2003	35.6	193.6	240.3	111.1	50.8	0	0	0	0	14	0	0	645.4	53.78
2004	161.1	291.4	676.3	115.2	0	0	0	59	0	0	0	0	1303.0	108.58
2005	103.7	360.1	368.8	328.7	0	30	0	11.2	0	23	0	0	1225.5	102.13
2006	707	501	224	300	24	3.5	23.2	5.2	0	27	0	0	1814.9	151.24
2007	24.2	579.8	392	157.8	61.8	13.6	0	9	0	0	0	0	1238.2	103.18
2008	74.2	341.4	329	65.4	47	33.5	143.5	0	0	0	0	0	1034.0	86.17
2009	103.5	349.5	143.5	380.6	29.9	6	0	0	96	0	0	13	1122.0	93.50
2010	64	249	105.4	344.6	88.8	0	0	0	0	0	0	125	976.8	81.40

The fluctuations in the rainfall effects the crops badly as the rainfall in October to December damage the crops also. (Dalal P. 2015)

Soil Sampling and analysis – The seasonal variation in Physico-Chemical Parameters of Grassland Soil is

Table 2:

Parameters	Summer	Rainy	Winter
pH	8.26	8.11	8.11
Temperature (°c)	38.00	27.00	20.00
Moisture Content (%)	10.81	36.02	21.43
NH_4-N (mg/Kg)	25.36	41.25	19.81
NO3-N	19.00	39.23	18.52
Water Holding Capacity (%)	48.00	43.00	43.00
Total Nitrogen (%)	0.10	0.18	0.16
CO_3 (meq/L)	0.25	0.28	0.29
HCO_3 (meq/L)	3.75	3.8	3.8
Na^+ (meq/L)	26.19	28.69	29.32
Cl^- (meq/L)	14.01	18.2	13.5
K (meq/L)	0.12	0.13	0.12
Mg^{++} (meq/L)	7.25	7.25	7.3
Ca^{++} (meq/L)	0.75	0.80	0.87
Available N (kg/ha)	186.72	198	186
Available P (kg/ha)	16.87	18	16
Available K (kg/ha)	116.20	118	116

Flux Measurements –

Three places were selected for sampling of N_2O fluxes. The collection of air is been done by closed chamber technique (Jonasson & Granat 1984) during December 2014 to January 2016. For sampling a transparent glass box (of dimensions 50L x 35W x 15H) is been taken by digging a narrow gully of the frame in summer and winter only. In the rainy season as the soil is too wet, no digging is been required. The base is made up of aluminum and is been installed to 2 hrs before the sampling to maintain the stabilized conditions. The glass chamber is been pushed and locked in the groove of aluminum for sampling, covering an area of 0.18m^2. The system was made airtight by filling the aluminum frame with water. A hole of 5mm is done in a glass for sample syringe insertion. Before sampling the air in the chamber is mixed by pressing the pump for at least 5 mins. The glass syringe is been inserted in a rubber cock twice or thrice in the chamber. The air samples for the measurement is evacuated in sealed glass vessel at 0 min, 10 min & 20 min each time the ambient air is also been collected to measure flux.

The collected nitrogen is been brought to analysis by a gas chromatograph present in department of Chemical Engineering Ujjain Engineering College, Ujjain. The operating temperature of detector is 360°c, for injector is 160°c and oven is 80°c with nitrogen as a carrier gas at a flow rate of 30ml/min.

Calibration done before measurements for that the primary standards of 211 and 1242 ppb of N2O are been taken. 1 mL of air sample was injected with 2 mL glass syringe and the peak areas are been recorded and averaged for each flux measurement. The N_2O flux is been carried out using formula

$$F = \frac{33\mathrm{T\ x\ BV}}{28\ \mathrm{x}\ 1000\mathrm{tA}}$$

Where:

- F = Flux of N2O in µg/m^2/hr
- T = Change in concentration of N_2O from o to t mins
- BV = Box Volume in cm^3
- A = Soil area within chamber in m^2

Result–

The N2O emission in this study was 3.81 Kg/hr/Yr which is a higher rate than standard.

Conclusion –

Over all result of the present study provides intriguiting information about source-sink potential with seasonal variability and gradient of factors that control the fluxes of N_20. Crucial habitat factors inducing high variability in N_20 production and emission are difficult to predict and generalize from inter-site soil variables. The large variation of N_20 fluxes in time illustrates the difficulty in estimating representative fluxes. More study is needed to enhance our knowledge of how soil, vegetations and climatic factors control N_20 emission rates and they may provide a reliable information for the extrapolation of N_20 fluxes to larger areas and for predicting emission rates under changing conditions.

Seasonal pattern in N_20 Emissions:

Emissions of N_20 from the grassland soils are highly stochastic, both in space and time. In this Study variation of N_20 emission with time was high with flux rate ranging from -710 to 2300 µgm^2/d.

N_20 fluxes were high during growing season followed by summer and winter (velthof *et al.* (1996) and Mosier *et al.* (1997) they report that N_20 emissions peak soon after rainfall and low during cold part of the years and also during hot dry periods. The N_20 fluxes were high during rainy season is probably due to ideal combination of high soil moisture and increasing temperature during this season (Schmidt *et al.,* 1988; Ambus and Christensen, 1995). High N_20 fluxes during rainy season when $N0_3$-N and soil moisture was higher with warmer temperature and high net nitrification rate may be due to strong coupling of nitrification and de-nitrification in soil (Allen *et al.,* 1996). De-nitrification in anaerobic micro sites could also be involved in the production of N_20 in aerobic soil when the nitrification rate is high. .This would, most likely occur under warm temperatures, high soil moisture and near neutral to alkaline pH. Rapid nitrification would lower the microenvironment 0_2 supply and increase $N0_3$-N concentrations would limit 0_2 diffusion (Goodroad and Keeney, 1984).

Low N_20 fluxes during winter season may be due to lower mean temperature would result in a combination of decreased microbial activity, increased N_20 solubility and lower gaseous diffusion. The net effect would be decreased N_20 emissions from the soil (Goodroad and Keeney, 1984 and Mosier *et al.,* 1996). Velthoff *et al.* (1996) also observed same trend as in this study and reported large N_20 emission during spring, summer and autumn and relatively low during winter season from grassland in the Netherlands.

On occasions, small sink activity for N_20 has also been observed which may have been related to greatly reduced rate of diffusion to N_2 (Ryden, 1981; Keller *et al.,* 1986). Other observations of such a soil sink of N_20 were reported by Clayton *et al.* (1997) and Smith *et al.* (1998). In Eastern Amazonian grassland Verchot *et al.* (1999) observed soil uptake of N_20 during dry season. They further observed that negative fluxes in dry season are curious because reduction of N_20 via denitrification is not expected in dry and toxic soil condition. The mechanism for these negative fluxes is unknown provide a substantial supply of substrate to denitrify during rainy season when anoxic soil condition appears. During the present study, it was not possible to distinguish between nitrification and denitrification as the source of N_20. The significant correlation between N_20 flux-and soil NH_4^+-N levels indicate that nitrification plays a vital role in N_20 emissions. The N_20 flux due to nitrification was found to be strongly correlated with soil NH_4^+ level (Parton *et al.,* 1988)

Climatic Factors and N_20 Fluxes:

N_20 emissions showed considerable variation over time (monthly) were not correlated with soil temperature and soil moisture in present study. Ambus and Christensen (1995) also have not observed any correlation with these soil variables in Danish grassland field. Absence of relationship is most probably due to effect of these variables are masked by other soil variables. Matson *et al.* (1991) also did not observed any relation between soil moisture and temperature with N_20 fluxes in local ecosystems, while several studies concur the N_20 emission increases with soil moisture (Davidson *et.al.,* 1993; Mosier *et.al.,* 1996; Epstein *et.al.,* 1998) and

Poor relationship between soil moisture and N_20 fluxes ($r = 0.18$, $p < 0.41$, $n = 22$) in this study does not mean that soil water is an unimportant factor controlling the nature of the N_20 emissions from soil. Rather, these results suggest that the importance of soil water is more apparent when nitrogen is cycling rapidly during rainy season when nitrogen mineralization was highest and N_20 fluxes are more

substantial. Several other studies also indicate that interaction among soil warming, moisture availability, nitrogen cycling and plant physiological activity may control N_20 fluxes (Parton *et al.,* 1988; Matson *et.al.,* 1991; Li *et.al.,* 1992; Epstein *et.al.,* 1998) so that direct correlation between N_20 fluxes and any one of the variables was typically very low.

Grazing by livestock has been also shown to increase N_20 emissions from grassland, both by creating localized concentration of mineral N through the deposition of urine and dung, and by subjecting the soil to compaction by hooves and thus reducing the air-filled pore space (Velthoff and Oenema, 1995; Oenema *et al.,* 1997). Nutrient transformations and nutrient availability in such excretal patch areas are of central importance to the fertility and productivity of grazed grassland (Richards *et al.,* 1976; Saunders, 1984).

These results indicated that factors inducing high N_20 production are difficult to predict from soil factors. The fact that controlling factors may vary during the years and that these factors might amplify or counter act each other in their effect on the N_20 emission may have contributed to this general lack of a significant correlation (Robertson, 1994). Results of Clayton *et al.* (1997) from the grassland site produced generally poor correlation with soil and environmental variables, same as in present study, and thus provided little basis for flux predictions. The reason was that different variables are the principal controller at different times. If the mineral nitrogen is very low, increase in temperature or soil moisture may not result in increased emission; at low temperature increase with mineral N content may be small. If the soil is too dry for microbial activity, there is little or no response even to heavy application of N fertilizer, or to a temperature change (Smith *et al.,* 1998).

References:

1. Dalal P. Pollution Pattern during the Decade 2001-2010 at Ujjain Our Earth ISSN 2249-3832 Vol. 7(3) 2010 Pg. 26-28
2. Dalal P. Impact of Water Quality on Crop Production in Ujjain District African Journal of Agricultural Science and Technology ISSN 2311-5882 Vol 3(9) 2015 Pg. 392–397
3. Bollmann A, Conrad R (1998). Influence of 0_2 availability on NO and N_20 release by nitrification and denitrification in soils. Global Change Biol. 4 : 387-396.
4. Comfort SD, Kelling KA, Keeney DR, Converk JC (1990). Nitrous oxide production from injected liquid dairy manure. Soil Sci. Soc. Am. J. 54 : 421-427.
5. Conrad R (1996) Metabolism of nitric oxide in soil and soil microorganisms and regulation of flux into the atmosphere. In : Murrell JC, Kelly DP Microbiology of atmospheric trace gases : sources, sinks and global change processes. Springer, Berlin, Heidelberg New York, pp 167-203.
6. Crutzen PJ (1979) The role of NO and N_20 in the chemistry of the troposphere and stratosphere. Annu Rev Earth Planet Sci 7 : 443-472.
7. Crutzen PJ and Ehhalt DH (1977) Effects of nitrogen fertilizers and combustion on the stratospheric ozone layer. Ambio. 6 : 112-117.
8. Davidson EA (1991) Fluxes of nitrogen oxide and nitric oxide from terrestrial ecosystems. In : Rogers JE, Whitman WB (Eds) Microbial production and consumption of greenhouse gases : Methane, Nitrogen oxide and Halomethanes. American Society for Microbiology, Washington DC, pp 219-235.

9. Davidson EA, Swank WT, Perry TO (1986). Distinguishing between nitrification and denitrification as sources of gaseous nitrogen production in soil. Appl. Environ. Microbiol. 52 :1280-1286.
10. Dentener F and Raes F (2002) Greenhouse gas and atmospheric chemistry: towards integration of air pollution and climate change policies. In : Van Ham J. *et al.* (eds) Non-C02 Greenhouse Gases : Scientific Understanding, Control Options and Policy Aspects. Millpress Scince Publisher Rotterdam, The Netherlands pp. 1-14.
11. Dobbie K. E. & Smith K. A. (2001). The effect of temperature, waterfield pore space and land use on N_20 emission from an imperfectly drained gleysol. Europian Journal of soil Science 52, 667-673.
12. Epstein HE, Burke IC, Mosier AR, Hutchinson GL (1998). Plant functional type effects on trace gas fluxes in the short grass steppe. Biogeochem. 42 :145-168.
13. Firestone MK and Davidson EA (1989) Microbiological basis of NO and N_20 production and consumption in soil. In : Exchange of trace gases between terrestrial ecosystems and the atmosphere (eds. MO Andreae and DS Schimal, John Wiley & Sons. Inc. New York, pp 7-21.
14. Flessa H, Dorsch P and Beese F (1995) Seasonal variation of N_20 and CH_4 fluxes in differently managed arable
15. Keller M, Kaplan WA and Wofsy SC (1986) Emissions of N_20, CH>. and $C0_9$ from tropical forest soils. Journal of Geophysical Research, 91: 11791-11802.
16. Keller M, Veldkam E, Weltz AM and Reiners WA (1993) Effect of pasture age on soil trace-gas emissions from a deforested area of Costa Rica. Nature 365 : 244-246.
17. Khalil MAK (1999) Non-$C0_2$ Greenhouse gases in the atmosphere. Annu Rev Energy Environ 24: 645-661.
18. Khalil MAK and Rasmussen RA (1988) Nitrous oxide: Trends and global mass balance over the last 3000 years. Annals of Glaciology 10 : 73-79