Estimation of nitrous oxide by irrigation in parks with treated wastewater in the city of Chihuahua, Mexico

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INTRODUCTION

Nitrous oxide is very important in the environment because it is a potent greenhouse gas with a global warming potential of 170-290 times greater than carbon dioxide [1]. This gas is considered to be responsible for approximately 6% of the total effect of the greenhouse and its concentration at the substation is increasing at a rate of 2% per year [2].

Calculations on models indicate that concentrations of N_2O in the atmosphere are ranging values from 354 to 460 ppb by the year 2100, compared to the current concentration of 316 ppb [3]. It has recently been recognized that the migration of nitrous oxide into the stratosphere contributes to the destruction of the ozone layer [4]. This gas is not lost in the atmosphere; its mechanism of elimination is to be transported to the stratosphere, where it is photolytically oxidized to nitric oxide, which reacts with the stratospheric ozone, destroying the ozone layer [5].

The N_2O not only comes from the processes of biomass burning (vegetable debris, oil combustion and volatilization from fertilized soils), also derives from microbial activity in Wastewater treated (TWW), soils and ocean, during the degradation of nitrogenous organic matter [6], such as nitrates, ureas and proteins from dead organisms. These components come from the organic residues of households and industries that usually have as final destination the different treatment plants [7]. Subsequently, effluents are discharged into rivers, lakes, estuaries or used for parks and gardens irrigation, where nitrification and denitrification processes can generate direct N_2O emissions, such processes can occur in the plant and in the bodies of water where the effluent is received [7].

Recent techniques of isotopic monitoring have made it possible to identify the preferential routes of nitrogen and its derivatives in situ, which indicate that the non-selective nitrification of ammonium ion is the main route for the formation of N_2O in aquatic systems [8].

It is difficult to obtain reliable estimations of N_2O concentration due to its spatial and temporal variability [9]. There are micro-meteorological methods which allow continuous measuring and monitoring of N_2O fluxes in a on a field scale, to be represented later in spatial and temporal manner [1]. However, these methods often require costly instruments and large field trials. The closed-chamber technique is a relatively inexpensive and easy-to-use method for measuring N_2O fluxes in a given area and comparing different treatments using small plots (typically <1 m2). The development of this technique coupled with gas chromatography (GC) can aid quantification of N_2O concentrations in field analysis and increase the frequency of sampling needed to overcome problems associated with temporal variability [9].

Zou et al., suggests that the emission of N_2O in ecosystems may be related to the role of crops and plants and the microorganisms they contain in the roots, due to the availability of nitrates and oxygen in the soil, which trigger the nitrifying processes [10].

Lysimeters are a fraction of soil in a small area previously characterized, its use for the study of water, nitrites and nitrates movement through the soil is an economical and reliable alternative to measure water pollution [11].

QUANTIFICATION OF N_2O THROUGH THE USE OF LYSIMETERS AND GIS TECHNIQUES IN CHIHUAHUA CITY

In the present work lysimeters with previously characterized soil and vegetation of the city of Chihuahua, Mexico were used. The production of N_2O was quantified by the closed chamber method and gas chromatography. The strategic objective of this work was to estimate the contributions of nitrous oxide generated in soils through the inorganic nitrogen compounds present in the TWW. Furthermore, the amount estimation of N_2O generated in parks and green areas of the city of Chihuahua by the use of TWW, matching the condition and emissions founded in lysimeters with a database generated by the use of geographic information systems techniques (GIS). The final result is the total estimation of N_2O in parks and green areas in the city of Chihuahua, Mexico.

Emissions of N_2O in lysimeters

In order to perform nitrous oxide measurements, the "Static Closed Chamber" method was used, using PVC cylinders 20 cm long and 3 cm in diameter, on a cylindrical base 15 cm in diameter and 3 cm high, buried in the soil. After the samples were taken, they were immediately transported to the laboratory to be read by gas chromatography. The determinations were performed in Perkin Elmer Chromatograph and ECD detector, with Carboplot capillary column, using carrier gas helium with flow of 40 ml / min; The working temperatures were 100 ° C for the injector, 35 ° for the furnace, 250 ° for the detector, and as carrier gas, nitrogen was used at 40 ml / min. For the certainty of the measurement, Sampling was performed once a week to give opportunity for the formation of nitrous oxide and avoid any gas leakage; also each measurement was made in triplicate for each sample.

Estimation of nitrous oxide emissions in parks and gardens in the city of Chihuahua, Mexico.

The emission of parks and gardens were obtained with the crossing of the information of the green areas by Geographic information systems techniques (GIS), with the emission obtained in the lysimeters. For this we identified the geometric characteristics of the green areas as surface and perimeter of the polygons of existing parks, type of vegetation, irrigation period and type of irrigation (drinking water or TWW), identifying the predominant soil in the polygon, and subsequently spatial and temporal behavior maps of the N_2O emission were elaborated.

RESULTS

The concentrations of nitrous oxide in lysimeters irrigated with ART are much higher than those irrigated with drinking water and because no concentrations were found in the lysimeter of drinking water, for this reason it were not considered for analysis. Illustration 1 shows the emission estimating in parks and green areas calculated by the use of lysimeters and GIS thechniques during the measurement period in Chihuahua City (January-June 2013).

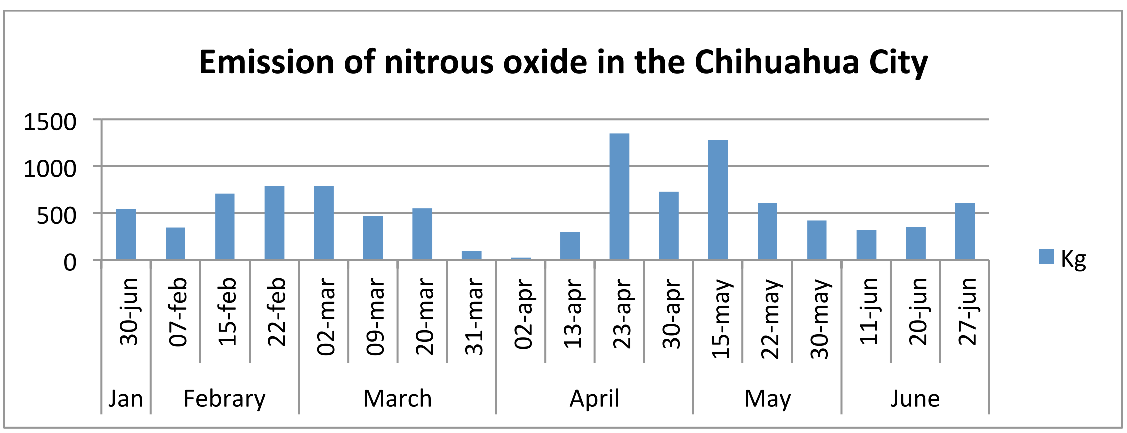

Illustration 1 Nitrous oxide emission in the city of Chihuahua during the measurement period (Jan-Jun 2013)

In the city of Chihuahua there are 1474 areas considered as green areas, among which parks, ridges, golf camps and gardens with a total area of 4834643 m^2, of which 12 have no vegetation with an equivalent surface of 16667 m^2. These areas were left out of the calculation of emissions. The analysis also showed that there are 502 green areas that are irrigated with drinking water and are equivalent to 1226627 m^2, approximately 26% of the territory occupied by green areas. Likewise, in the city there are a total of 957 green areas that are irrigated with TWW and occupy an area of approximately 3591348 m^2.

According to the estimation of the emissions obtained by GIS techniques, a total of 9932 kg of N_2O was emitted during the six months of measurement period, an equivalent of 11.5 mg of N_2O m^2 day-1. Illustration 2 shows how these estimates are distributed on a specific measurement day. The highest emissions are seen in an area used as a golf camp (1), a green area near the south treatment plant of the city, where there is a lot of vegetation (2) and the rest of the main parks in the city of Chihuahua which have a larger area (3).

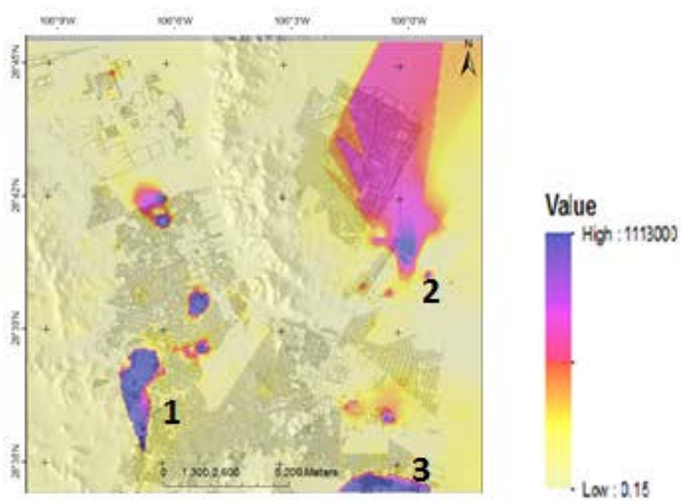

Illustration 2 Distribution of N2O emissions in the city of Chihuahua on 01-15-2013

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