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Emission of Nitrogen Species and Biomass Burned Comparison Over India and Indo-Gangetic Plain

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Abstract: In this study, we used a data from MODIS burned area Data (MCD64A1) which is downloaded from FileZilla. The FileZilla Client and FileZilla Server are separate components of the open-source, cross-platform FTP application FileZilla. Here we can download MODIS burned data file. We download MODIS burned file in GeoTIFF image file format so that we can easily extract data for desire area. This MODIS burned data is extracted with the help of ArcMap. After the extraction of data for desire study area and we get number of pixels burned in study area. To get burned area we multiply the number of pixels to the area of pixels. We found that In India without IGP pre-monsoon burned area higher than the post-monsoon burned area and in IGP post-monsoon burned area is higher than the pre-monsoon burned area. We also conclude that in year 2016, 2018, 2019 and 2020 IGP post-monsoon burned area 23903960538 m^2, 21892394111 m^2, 20998770054 m^2 and 20348568933 m^2 respectfully has highest compare to other area and month for that year and in year 2017 India without IGP per-monsoon burned area 22453082565 m^2 is higher compare to other area and month. In this study, we also calculate nitrogen emission and found that emission of nitrogen species in IGP region post-monsoon has the highest as compare to emission of nitrogen species in IGP region pre-monsoon as well as emission of nitrogen species in India without IGP region.
Keywords: Biomass burning, Nitrogen species, Emission, Air Pollution, Indo-Gangetic plain

I. INTRODUCTION

A substance is said to be polluting the air when it endangers the health of humans, other living beings, the environment, and materials. Gases (such as ammonia, carbon monoxide, sulphur dioxide, nitrous oxides, methane, carbon dioxide, and chlorofluorocarbons), particles (both organic and inorganic), and living things can all contribute to air pollution. Air pollution may have detrimental consequences on the built environment, the natural environment (such as climate change, ozone depletion, and habitat loss), and other living things in addition to affecting people, animals, food crops, and other living things (for example, acid rain). Both natural occurrences and human actions have the ability to cause air pollution. Outdoor air pollution alone is one of the leading causes of death, accounting for 2.1 to 4.21 million fatalities annually. Air pollution, which kills over 7 million people yearly and results in a global mean loss of life expectancy (LLE) of 2.9 years, is the worst environmental health problem in the world (Kum et al., 2020).

In 2019, India is home to 21 of the world's 30 most polluted cities. 13 of the world's 20 cities with the highest yearly air pollution levels are in India, where at least 140 million people breathe air that is 10 times or more polluted than the WHO acceptable limit, according to research based on 2016 statistics. Agriculture burning contributes 17% of pollution, automobiles 27%, and other sources 5%. 51% of all pollution is caused by industrial activity (Singh et al., 2020). In India, air pollution results in 2 million premature deaths annually. While industry and automobiles both release pollutants, biomass burning for cooking and heating is a substantial source of pollution in rural regions. Large-scale crop residue burning on agricultural fields is a substantial source of smoke, haze, and particle pollution in the fall and spring as a less expensive alternative to mechanical tilling. Despite having low per capita emissions, India is the third-largest emitter of greenhouse gases in the world after China and the United States (Badarinath et al., 2009).

Biomass burning like, managed burns, and agricultural burns etc and it is known as release huge amounts of pollutants into the sky, due to this poor air quality on a local and zonal scale (Casey et al., 2019). Biomass burning are the primary source of air pollution and it emits lot of gases species and particulate matter. It can be form natural and manmade. Man-made burning includes vegetation burning for land clearance and land-use change, as well as fuelwood burning, whereas natural burning includes lightning-caused fires. Man-made burning is thought to be responsible for approximately 90% of all fires on the earth, with natural burning playing a minor role. Natural forest burning, which are usually caused by lightning, are not a huge global threat. These burning are particularly dangerous in mid- to high-latitude woods, where lightning is a more important role than human-caused fire.

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This is due to the fact that lightning-caused fires typically originate in remote areas that are difficult to reach by fire crews and might linger undetected for days. As a result, lightning-caused forest fires typically cover considerably bigger regions than burning started by humans. Biomass burning is a worldwide (e.g., in Asia, Africa, South America, and North America) phenomenon with substantial consequences for climate change, the environment, human health, biodiversity, and land use. Around 90% of biomass burning is thought to be caused by humans, with the remaining 10% caused by atmospheric lightning.

Burning biomass contributes significantly to the troposphere's emissions of gaseous and particulate pollution. 20% to 30% of the CO2 emissions and chemically reactive gases such hydrocarbons, CO, and NOX worldwide are produced by burning biomass. Burning biomass also generates around 42% of the world's black carbon (BC) and 74% of its primary organic carbon (OC). These compounds have an impact on climate change, air quality, atmospheric chemistry, and human health (Lifei Yin et al., 2019).

In many years, in India biomass burning become a serious matter because due to this air pollution increases and In India more than half of the Indian population lives in locations where the government's safety standards for the quality of the air are not met. The disease burden is likewise significant, with more than 1.1 million fatalities in India attributed to air pollution in 2015(Singh, Prachi et al., 2021). In Asia, emissions from burning biomass account for 20–30% of total emissions for some species, such as carbon monoxide (CO) and volatile organic compounds (VOCs). The aerosol and gaseous species budgets in Asia are significantly impacted by the emissions from biomass burning in India. Approximately 25% of black carbon, organic matter, and CO emissions in India between 1995 and 2000 were reportedly produced by open burning sources (Sahu, L. K et al., 2015). Biomass burning (agricultural) occurs mostly in pre monsoon (March, April and May) and post monsoon (October and November) throughout the year and spreads especially over the Indo-Gangetic Plains. Burning organic material releases enormous volumes of reactive nitrogen species (NH_3, NO_x, N_2O), carbon monoxide (CO), sulphur dioxide (SO_2), lead, mercury, and other dangerous air pollutants (HAPs). These gases can also help to the formation of secondary fine particulate matter both local and zonal scale. Every year, 7 million people die prematurely due to air pollution, the majority of which is caused by $PM_{2.5}$ (He, Linchen et al., 2022). Shortness of breath, coughing, sneezing, runny nose, and irritation of the eyes, nose, throat, and lungs can all result from exposure to fine particles. Exposure to fine particles can worsen medical conditions including asthma and heart disease as well as harm lung function (Vincenti, Beatrice et al., 2022).

II. STUDY AREA

In this study, comparison between two study area is been taken out i.e. India without IGP and IGP. In India biomass fire rage throughout the Indo-Gangetic Plains (IGP; mostly in Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal) happen every year. The Indo-Gangetic Plain, also known as the North Indian River Plain, is a 700-thousand-square-kilometer (172-million-acre) fertile plain that spans the northern Indian subcontinent, covering much of northern and eastern India, nearly all of Pakistan, and the southern lowlands of Nepal (Taneja et al., 2014). Mostly biomass burning happen in IGP region Punjab, Delhi, Haryana, Uttar Pradesh, Bihar and West Bengal as shown in figure 1.

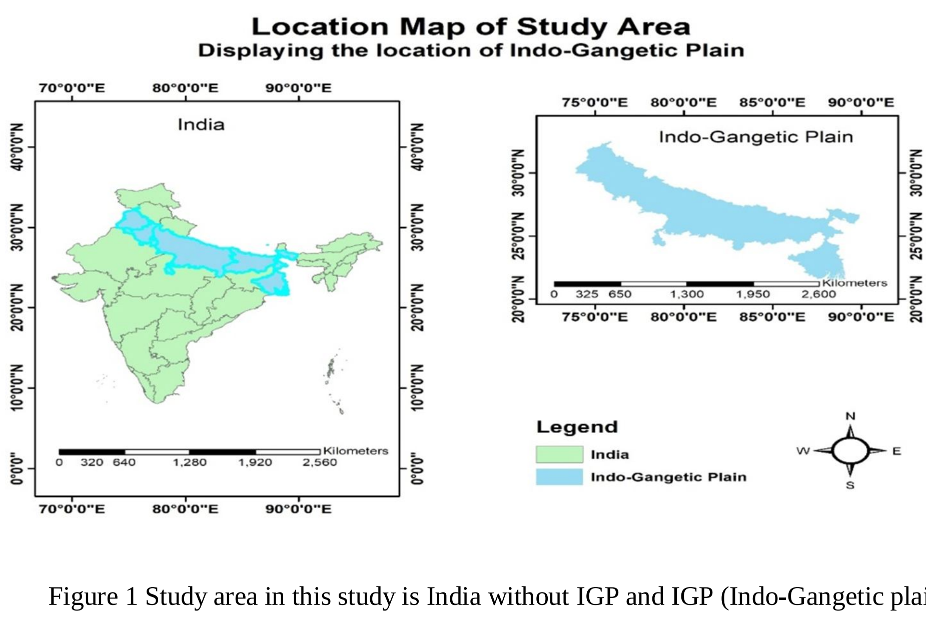

Figure 1 Study area in this study is India without IGP and IGP (Indo-Gangetic plain)

III. DATA AND METHODOLOGY

A. Emission of Nitrogen species

Based on the following equation (1), reactive nitrogen species emissions from burning biomass in the IGP were computed (Seiler and Crutzen, 1980):

$$Ei = A \times B \times F \times Fi \quad (1)$$

where F is the percentage of biomass burned in the fire, A is the burned area (m^2), B is the biomass loading (kg m^{-2}), Ei is the species i emission (g) (in this case, OC, NH_3, N_2O, and NOx), and Fi is the emission factor (g kg Biomass Burned^{-1}) of species i. The burned region was identified using the Moderate Resolution Imaging Spectroradiometer (MODIS) Burned Area product (MCD64A1, Collection 6). The biomass loading (kg m^{-2}), percentage of biomass burned in the fire and emission factor values are adapted from Bray et al., 2019 as shown in table 1.

	Uncertainty (April-May)	Uncertainty (Oct-Nov)
Fraction of Biomass Burned	0.013	0.426
Biomass Loading (kg m−2)	0.178	0.294
Emission Factor (g kg Biomass Burned−1)		
NH3	0.75	1.24
Nox	1.68	0.59
N2O	0.46	0.45
OC	0.03	1.2

Table 1 Uncertainties in each of the parameters used to calculate pollutant emissions

B. MCD64A1 MODIS Burned Data

In order to identify land areas that have been affected by a fire, the MODIS burnt area product (collection 6) often identifies a transition from a vegetation surface to char, ash, or dirt. The MCD64A1 burnt area product is created using daily MODIS (Aqua and Terra) surface reflectance images that has been educated using the MODIS active fire product. The dynamic threshold of the surface reflectance data is based on a burn-sensitive spectral band index produced from the MODIS 1240 and 2130 nm bands and is guided by the MODIS active fire hotspot locations. The product's resolution is supposedly 500 m. The burned pixels (1-366), unburned pixels ((0)), and unmapped pixels were all identified using the MCD64A1 Burn Date layer. The second layer, "Burn Date Uncertainty," is an estimated burn date uncertainty expressed in days. The burned area product is offered in hierarchical data format (HDF), and it contains the following layers that were used in this study: (1) "Burn date," and (2) "Burn Date Uncertainty." There may be a connection between the fire date ambiguity and the absence of a clear signal in the MODIS surface reflectance image (e.g. from clouds, but also other phenomena). The most recent MODIS collection 6 user's guide states that there is at least a one-day window of uncertainty for all burn pixels. Numerous geographic regions have been used to thoroughly validate the MODIS burnt area product and MODIS active fire product, and algorithm enhancements are continuing. For the last 10 years, we downloaded the free monthly HDF product from the University of Maryland FTP
(http://modisfire.umd.edu/pages/BurnedArea.php?target14Download) (January 2008 - December 2017).

C. Filezilla

The FileZilla Client and FileZilla Server are separate components of the open-source, cross-platform FTP application FileZilla. Here we can download MODIS burned data file. In this study we download MODIS burned file in GeoTIFF image file format so that we can easily extract data for desire area.

IV. RESULT

A. Burned Area

Burned area is compare between two study area i.e. India without IGP and IGP. Burned area in pre-monsoon (March, April and May) and post-monsoon (October and November) is calculated with the help of MODIS burned area product (MCD64A1) from year 2016 to 2020.

In this study we found that In India without IGP pre-monsoon burned area higher than the post-monsoon burned area and in IGP post-monsoon burned area is higher than the pre-monsoon burned area. In this graph we also conclude that in year 2016, 2018, 2019 and 2020 IGP post-monsoon burned area 23903960538 m^2, 21892394111 m^2, 20998770054 m^2 and 20348568933 m^2 respectfully has highest compare to other area and month for that year. In year 2017 India without IGP per-monsoon burned area 22453082565 m^2 is higher compare to other area and month as shoe in figure 2.

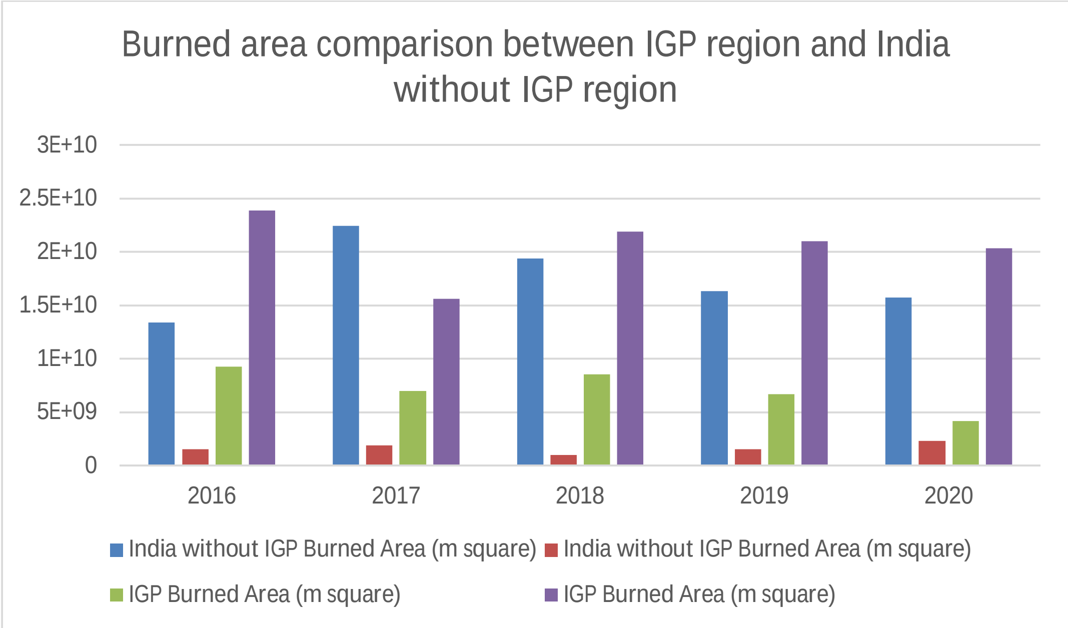

Figure 2 Burned area comparison between IGP region and India without IGP region

B. *Emission of Nitrogen Species*

In year 2016, Emission of nitrogen species in IGP region post-monsoon has the highest as compare to emission of nitrogen species in IGP region pre-monsoon as well as emission of nitrogen species in India without IGP region. Emission of nitrogen species in IGP region post-monsoon highest emission of NH_3, NOx, N_2O and OC are 3712346266g, 1766358304g, 1347222435g and 3592593160g respectfully.

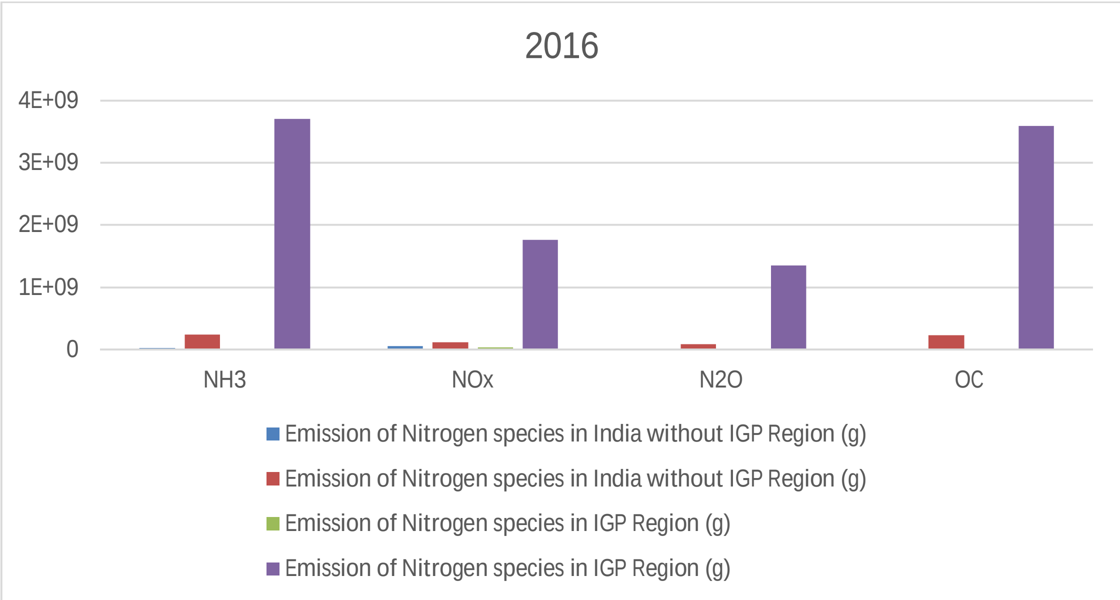

Figure 3 Comparison of emission of nitrogen species between India without IGP and IGP in year 2016

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In year 2017, Emission of nitrogen species in IGP region post-monsoon has the highest as compare to emission of nitrogen species in IGP region pre-monsoon as well as emission of nitrogen species in India without IGP region. Emission of nitrogen species in IGP region post-monsoon highest emission of NH_3, NOx, N_2O and OC are 2427203316g, 1154878997g, 880839913.2g and 2348906435g respectfully.

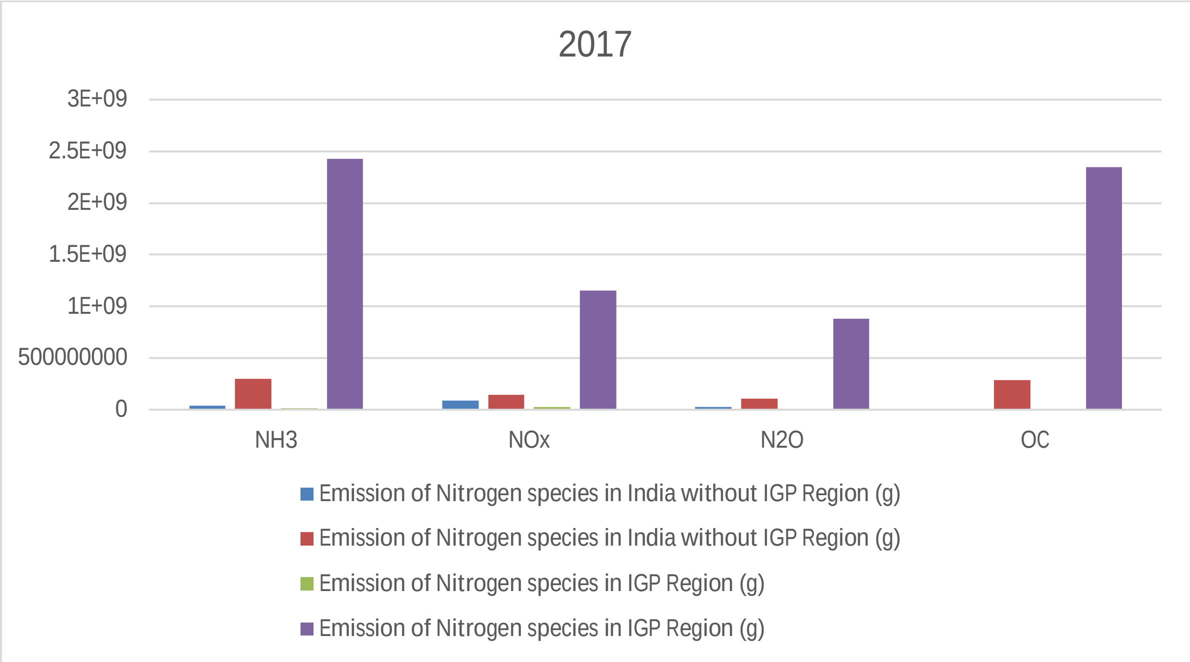

Figure 4 Comparison of emission of nitrogen species between India without IGP and IGP in year 2017

In year 2018, Emission of nitrogen species in IGP region post-monsoon has the highest as compare to emission of nitrogen species in IGP region pre-monsoon as well as emission of nitrogen species in India without IGP region. Emission of nitrogen species in IGP region post-monsoon highest emission of NH_3, NOx, N_2O and OC are 3399944850g, 1617715695g, 1233850954g and 3290269210g respectfully.

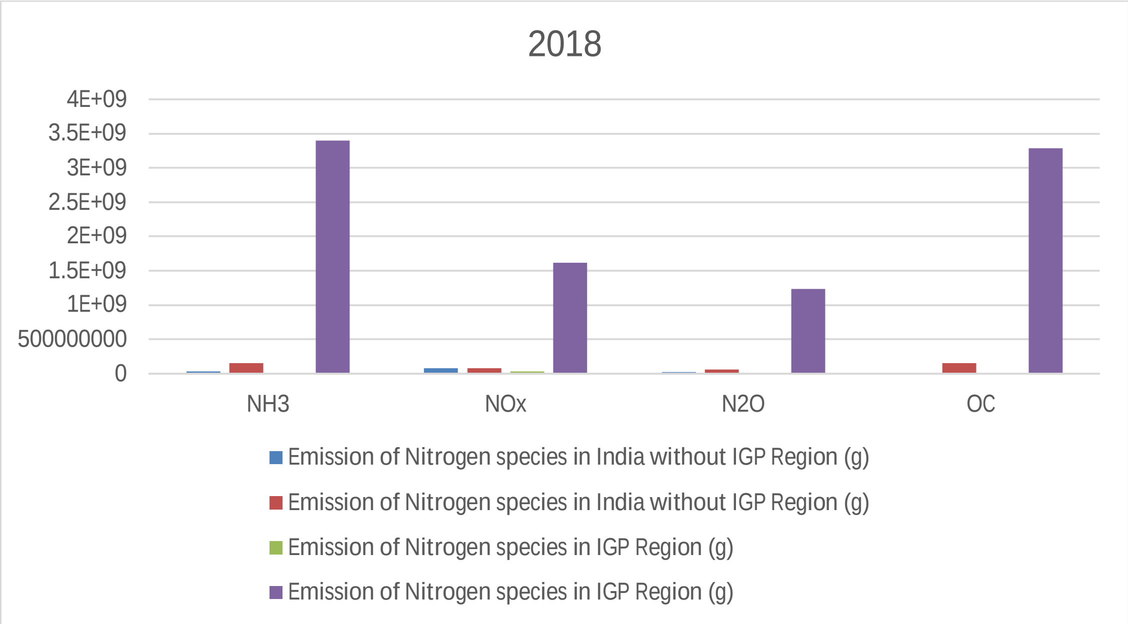

Figure 5 Comparison of emission of nitrogen species between India without IGP and IGP in year 2018

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In year 2019, Emission of nitrogen species in IGP region post-monsoon has the highest as compare to emission of nitrogen species in IGP region pre-monsoon as well as emission of nitrogen species in India without IGP region. Emission of nitrogen species in IGP region post-monsoon highest emission of NH_3, NOx, N_2O and OC are 3261162746g, 1551682274g, 1183486480g and 3155963948g respectfully.

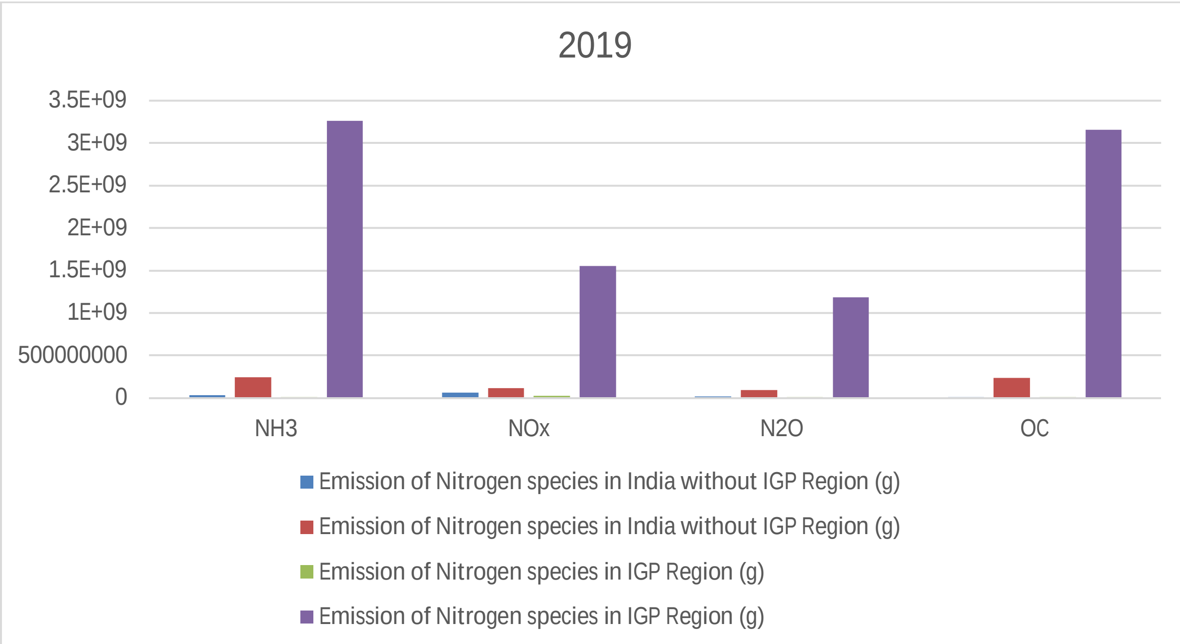

Figure 6 Comparison of emission of nitrogen species between India without IGP and IGP in year 2019

In year 2020, Emission of nitrogen species in IGP region post-monsoon has the highest as compare to emission of nitrogen species in IGP region pre-monsoon as well as emission of nitrogen species in India without IGP region. Emission of nitrogen species in IGP region post-monsoon highest emission of NH_3, NOx, N_2O and OC are 3160184848g, 1503636339g, 1146841275g and 3058243401g respectfully.

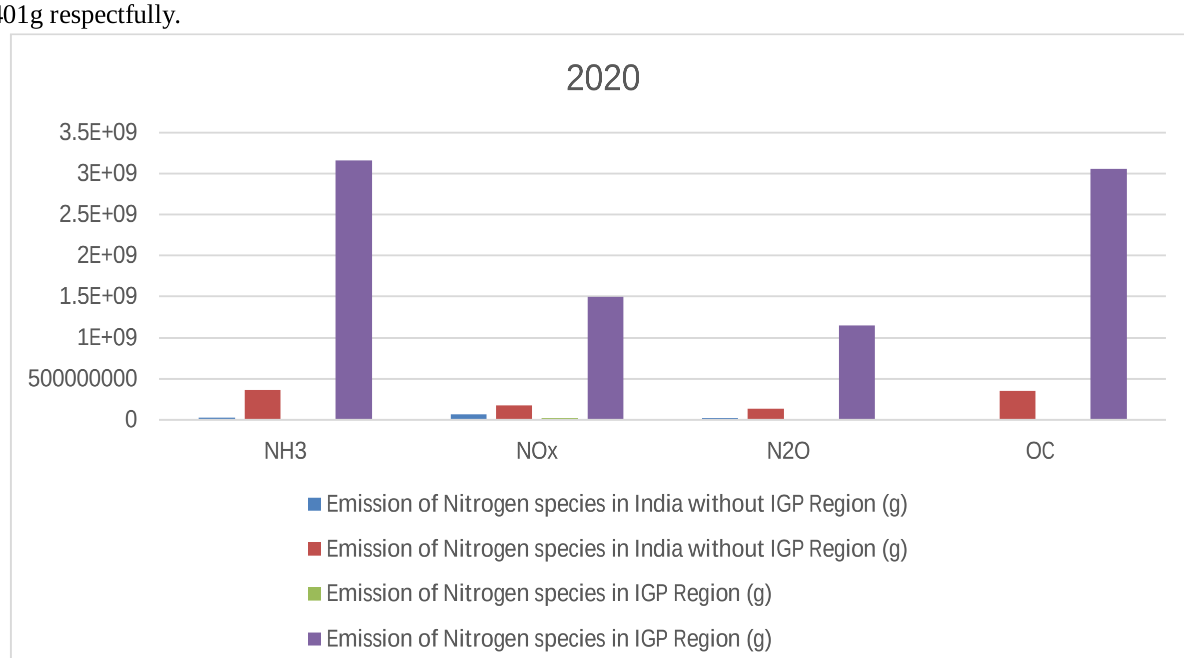

Figure 7 Comparison of emission of nitrogen species between India without IGP and IGP in year 2020

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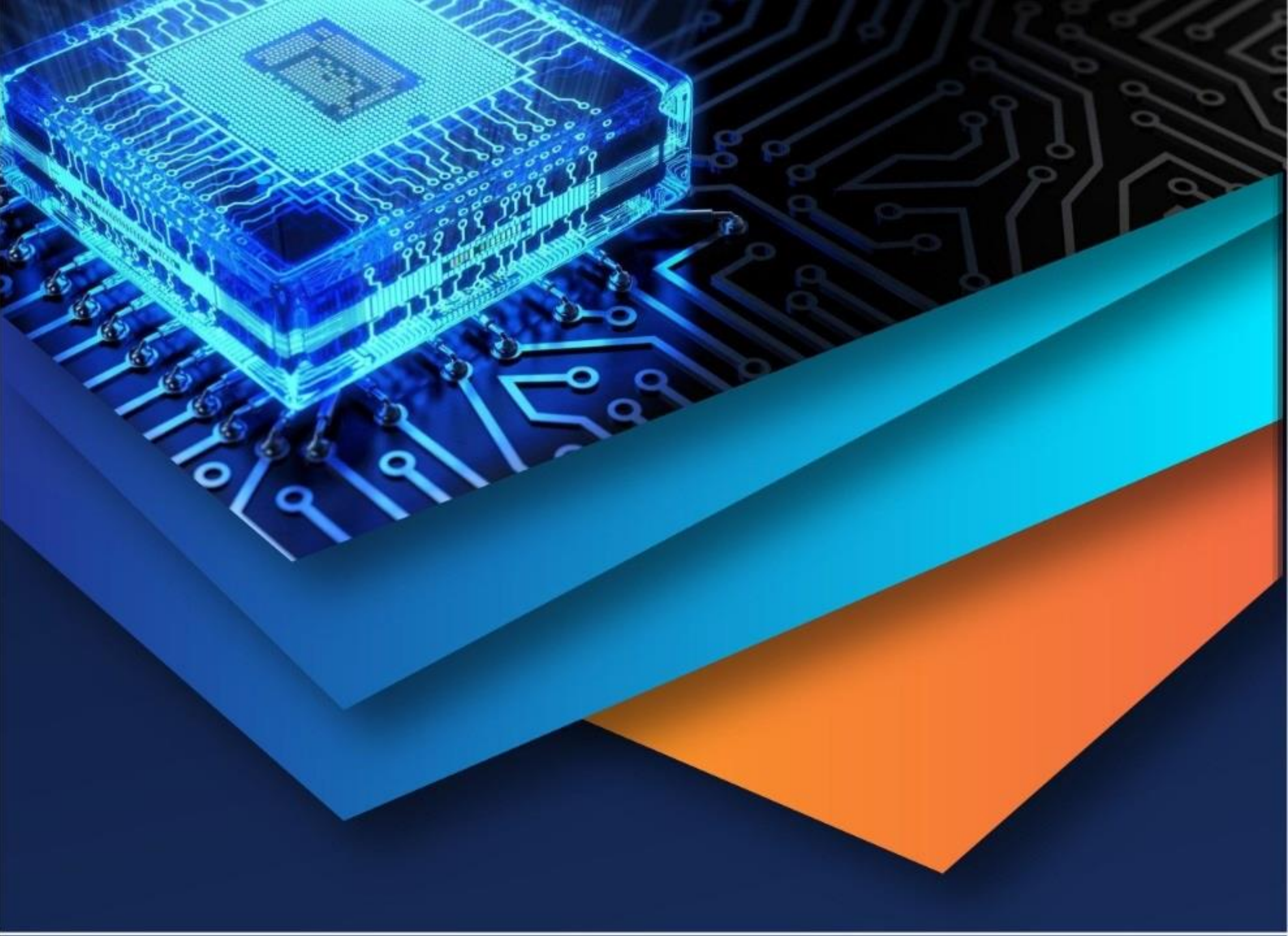

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