iJRASET
International Journal For Research in Applied Science and Engineering Technology



# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 9 **Issue:** IX **Month of publication:** September 2021

**DOI:** https://doi.org/10.22214/ijraset.2021.37935

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
*Volume 9 Issue IX Sep 2021- Available at www.ijraset.com*

# Preparing Municipal Solid Waste Emission Inventory and Spatial Distribution of Prayagraj City Using GIS

Ashish Shankar Singh[1], Dr. A. K. Shukla[2]
[1]*M. Tech Environmental Engineering, Department of Civil Engineering, Institute of Engineering and Technology, Lucknow*
[2]*Professor Civil Engineering Department, Institute of Engineering and Technology, Lucknow*

***Abstract:*** ***Pollutants in the air are emitted from a variety of sources in metropolitan areas, causing poor air quality. Using a Geographic Information System (GIS), this project attempts to assess municipal solid waste (MSW) burning emissions and prepare a spatial distribution grid for Prayagraj city. PM10, PM2.5, NOx, SO2, and CO emissions were computed using activity data and emission factors using a bottom-up approach. The result from this study shows that emissions for all 5 pollutants*** $PM_{10}$***,*** $PM_{2.5}$***,*** $NO_x$***,*** $SO_2$***, CO are 718, 488, 269, and 3771kg/day respectively, where CO is the highest emitted pollutant. The Prayagraj municipal area was divided into grids of 3 km*** $^2$ ***area. The spatial distribution plotted for Prayagraj city shows the hotspot grid areas for all 5 air pollutants emission. The hotspot grids for PM10 are P9, P10, P17, P29 and for*** $PM_{2.5}$***,*** $NO_x$***,*** $SO_2$***, are P9, P10, P17 and for CO are P9, P10, P14, P17, P29.***

***Keywords: PM10, PM2.5, NOX, SO2, CO, Emission Inventory, Spatial distribution, Hotspot grids***

## I. INTRODUCTION

Air pollution is the main problem in the city which has adverse impacts on climatic change and human health. Prayagraj city. The emission inventory is a document that details the amount of air pollutants released over a given period of time as well as the location of the emission source. A powerful instrument used by environmental government agencies to observe and manage emission sources is an emission inventory.

The emission factors are the crucial parameters for evaluating emission inventory. The Municipal solid waste is one of the major problems in urban areas whose proper collection and disposal management plan is not being implemented on ground level in present scenario.

The reason for increase in MSW is growth in living style, socio-economic expansion, population increment, industrial growth and increase in per-capita demand of packed and man-made things. The uncollected solid waste is thrown in an unorganised way which can be seen at road side, colonies corners, bank of river, etc.

This improper disposal of uncollected solid waste causes serious spread of diseases, soil quality is also affected and burning of this waste also results in air pollution. In India this scenario becomes more critical in festival times as India is multicultural country. Prayagraj city is considered to be holiest pilgrimage centres of India situated at confluence of three rivers- Ganga, Yamuna, Sarswati, so the MSW issue becomes an important consideration for the city. Through this study Prayagraj city emission inventory through MSW source is evaluated and spatial distribution for 3km$^2$ grid area are digitised using ARC-GIS.

## II. STUDY AREA

Prayaraj, Uttar Pradesh, India is in the Cities location category and is located at 25° 28' 22.9224" N and 81° 52' 42.0852" E in the India country. The city is 365 km2 in size and is located in southern Uttar Pradesh.With a population of 1.53 million people, Allahabad is the seventh most populated city in the state, thirteenth in Northern India, and thirty-sixth in India as of 2011. Allahabad is over 90 metres (295 feet) above sea level. Pratapgarh and Jaunpur are to the north, Mirzapur and Varanasi are to the east, and Banda and Fatehpur are to the west of Prayagraj city. City is separated from Madhya Pradesh by its southern border. Prayagraj city consists of 80 wards and the Prayagraj municipal boundary is divided into grids of 3km×3km area using ARC-GIS software for digitising spatial distribution map.

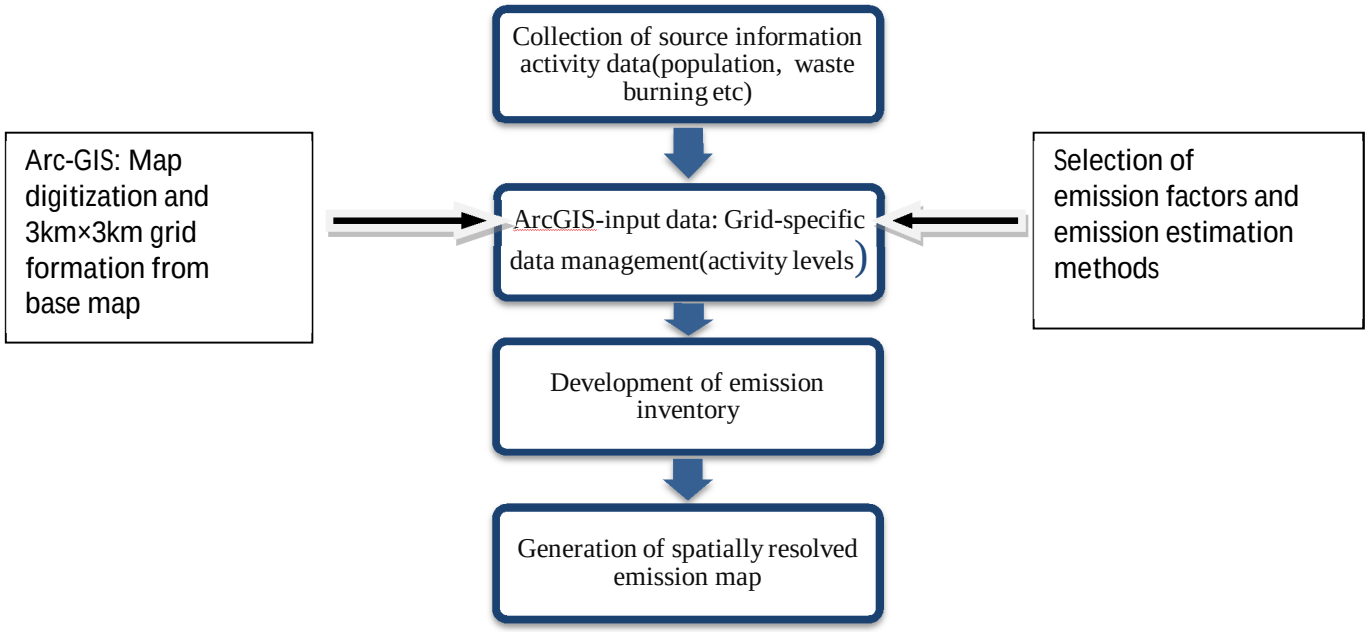
©IJRASET: All Rights are Reserved

## III. METHODOLOGY

### A. *Data Collection*

The population data of Prayagraj city ward wise was taken from the government of India census data. This total population data for the year 1991, 2001, 2011 was also taken from government of India census data and the new population was forecasted for the year 2021 using incremental increase method. The uncollected MSW efficiency data was taken from planning commission report of India 2014 and the dry waste and wet waste was also taken from literatures. The emission factors for calculating MSW emission were taken from UPPCB report and USEPA AP42

### B. *Steps Involved*



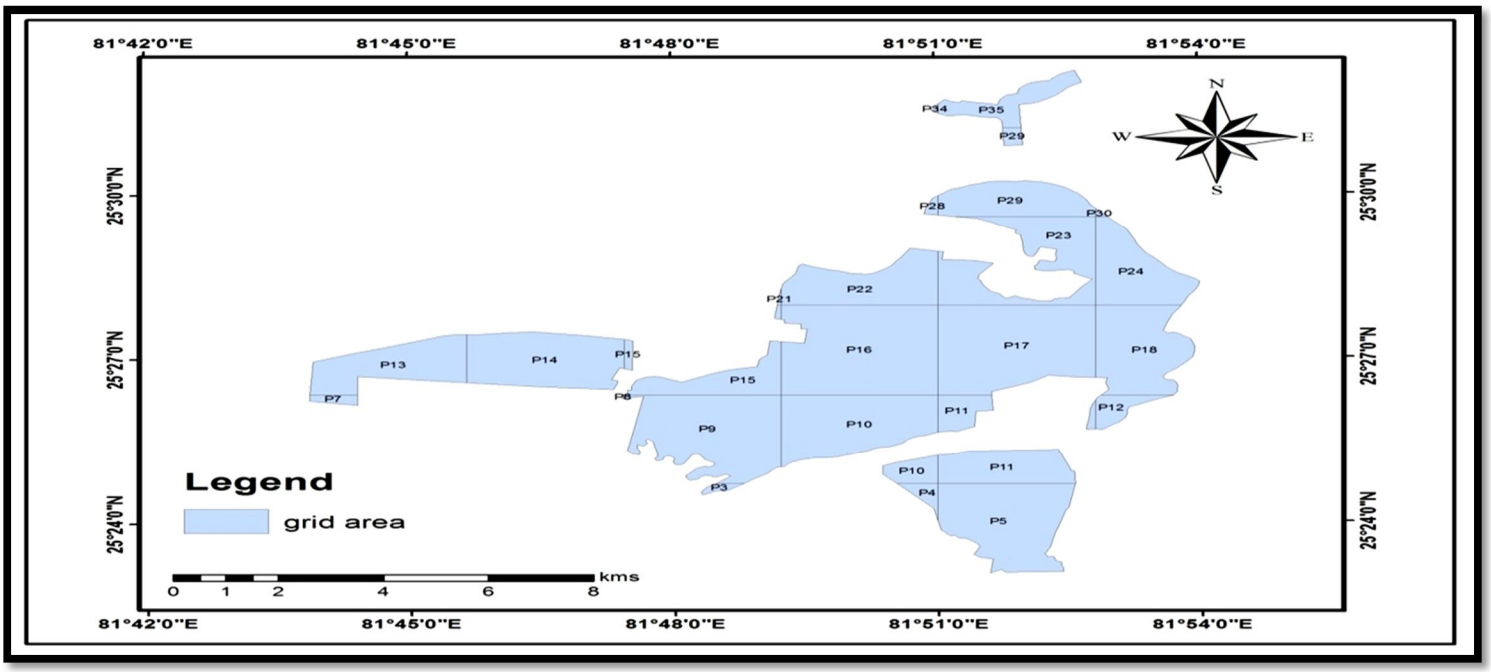




Fig:1- Digitised grid map using ARC-GIS

©IJRASET: All Rights are Reserved

*C. Formula and Emission Factors used*

*1)* The emission factors table given below which are used calculating emission for pollutants $PM_{10}$, $PM_{2.5}$, $NO_X$, $SO_2$, CO

| Pollutants | $PM_{10}$ | $PM_{2.5}$ | $NO_X$ | $SO_2$ | CO |
|---|---|---|---|---|---|
| Emission Factors | 8 | 5.44 | 3 | 0.5 | 42 |

*2)* Emission (kg/day) = Activity data × E.F

*3)* Population forecasting using incremental increase method –

$$Pn = P + n.x + \left(\frac{n(n+1)}{2}\right).y$$

Pn= population after $n^{th}$ decade
X=average increase
Y= incremental increase
P= actual population

*D. Preparation of MSW Emission Inventory and Spatial Distribution*

The emission of pollutants were calculated using the above formula ward wise of Prayagraj city. As the new population for the year 2021 was calculated using the incremental increase method considering the population from government of India census for the year 1991, 2001, 2011. The collection efficiency is 68%, so uncollected efficiency is 32 % of Prayagraj is taken into account, of which dry waste 20% is calculated and this dry waste is burned and emit air pollutants $PM_{10}$, $PM_{2.5}$, $NO_X$, $SO_2$, CO whose emissions are finally calculated. These pollutant values sheet is then join and related with the Prayagraj ward boundary and area is calculated in attribute table using ARC-GIS . Then grid boundary is opened which is intersected with ward boundary and values are distributed grid-wise. This change of ward emission to grid wise emission is done by calculating area and emission density for each pollutant in attribute table using field calculator. Then after the changed grid wise emission sheet is again join and related with grid boundary and finally emission values of each pollutant are spatially distributed and this spatial distribution is helpful in identifying most affected grids for each pollutant.

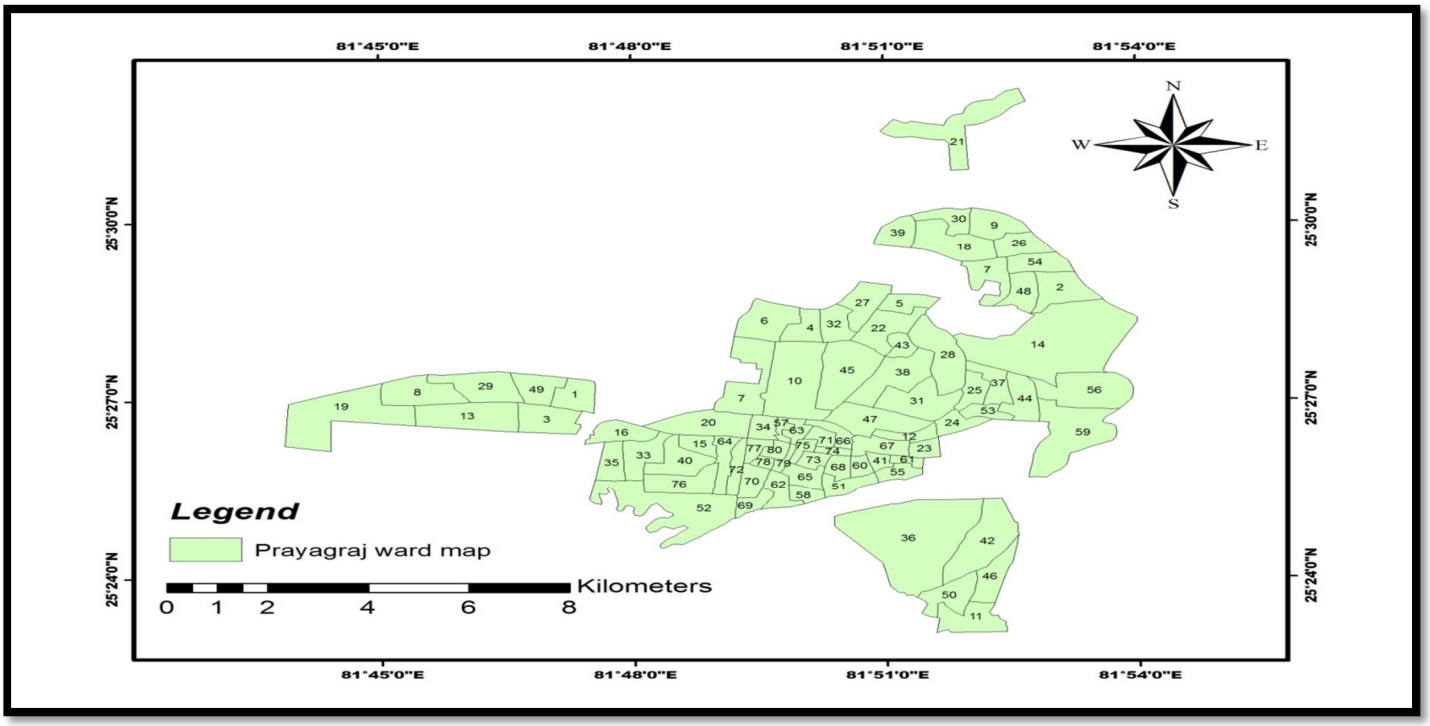



Fig:2- Digitised Prayagraj ward map using ARC-GIS

©IJRASET: All Rights are Reserved

## IV. RESULTS AND DISCUSSION

The collection efficiency of Prayagraj is 68% (taken from planning commission report 2014of India) and the dry waste which is burned found to be 20% of total uncollected solid waste which results in emission of air pollutants. As from Nagar Nigam report of Prayagraj city 540MT of solid waste is generated every day and so the average generation of solid waste per capita is 0.4kg/day taken from Uttar Pradesh Pollution Control Board (UPPCB) report.

Table: 1-Emissions Result

| Ward No | Population | new population | Waste Generation (kg/day) | Waste collection | UNCOLLETCTED | DRY WASTE | PM10 | PM2.5 | SO2 | NOx | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 8 | 5.44 | 0.5 | 3 | 42 |
| | | 2017980.259 | | | | | | | | | |
| Allahabad (M Corp.) WARD NO.-0001 | 17654 | 32022 | 12809 | 8710 | 4099 | 820 | 6.5580208 | 4.45945417 | 0.409876302 | 2.459258 | 34.42961 |
| Allahabad (M Corp.) WARD NO.-0002 | 12125 | 21993 | 8797 | 5982 | 2815 | 985 | 7.8822366 | 5.35992087 | 0.492639786 | 2.955839 | 41.38174 |
| Allahabad (M Corp.) WARD NO.-0003 | 15211 | 27590 | 11036 | 7505 | 3532 | 1236 | 9.8883877 | 6.72410362 | 0.61802423 | 3.708145 | 51.91404 |
| Allahabad (M Corp.) WARD NO.-0004 | 14056 | 25495 | 10198 | 6935 | 3263 | 1142 | 9.1375437 | 6.21352972 | 0.571096481 | 3.426579 | 47.9721 |
| Allahabad (M Corp.) WARD NO.-0005 | 15436 | 27998 | 11199 | 7616 | 3584 | 1254 | 10.034656 | 6.82356607 | 0.627165999 | 3.762996 | 52.68194 |
| Allahabad (M Corp.) WARD NO.-0006 | 11532 | 20917 | 8367 | 5689 | 2677 | 937 | 7.4967383 | 5.09778206 | 0.468546145 | 2.811277 | 39.35788 |
| Allahabad (M Corp.) WARD NO.-0007 | 6750 | 12243 | 4897 | 3330 | 1567 | 549 | 4.3880492 | 2.98387348 | 0.274253077 | 1.645518 | 23.03726 |
| Allahabad (M Corp.) WARD NO.-0008 | 20360 | 36930 | 14772 | 10045 | 4727 | 1654 | 13.235657 | 9.00024651 | 0.827202854 | 4.963371 | 69.4872 |
| Allahabad (M Corp.) WARD NO.-0009 | 12206 | 22140 | 8856 | 6022 | 2834 | 992 | 7.9348932 | 5.39572736 | 0.495930823 | 2.975585 | 41.65819 |
| Allahabad (M Corp.) WARD NO.-0010 | 16600 | 30110 | 12044 | 8190 | 3854 | 1349 | 10.791351 | 7.33811847 | 0.674459419 | 4.046757 | 56.65459 |
| Allahabad (M Corp.) WARD NO.-0011 | 13654 | 24766 | 9906 | 6736 | 3170 | 1110 | 8.876211 | 6.03582347 | 0.554763187 | 3.328579 | 46.60011 |
| Allahabad (M Corp.) WARD NO.-0012 | 12196 | 22122 | 8849 | 6017 | 2832 | 991 | 7.9283924 | 5.39113068 | 0.495524522 | 2.973147 | 41.62406 |
| Allahabad (M Corp.) WARD NO.-0013 | 13375 | 24260 | 9704 | 6599 | 3105 | 1087 | 8.6948383 | 5.91249004 | 0.543427393 | 3.260564 | 45.6479 |
| Allahabad (M Corp.) WARD NO.-0014 | 14163 | 25689 | 10276 | 6988 | 3288 | 1151 | 9.2071024 | 6.26082964 | 0.57543439 | 3.452663 | 48.33729 |
| Allahabad (M Corp.) WARD NO.-0015 | 8681 | 15746 | 6298 | 4283 | 2015 | 705 | 5.6433563 | 3.83748232 | 0.352709772 | 2.116259 | 29.62762 |
| Allahabad (M Corp.) WARD NO.-0016 | 9540 | 17304 | 6922 | 4707 | 2215 | 775 | 6.2017762 | 4.21720785 | 0.387611015 | 2.325666 | 32.55933 |
| Allahabad (M Corp.) WARD NO.-0017 | 16631 | 30166 | 12066 | 8205 | 3861 | 1351 | 10.811503 | 7.35182219 | 0.675718951 | 4.054314 | 56.76039 |
| Allahabad (M Corp.) WARD NO.-0018 | 15593 | 28283 | 11313 | 7693 | 3620 | 1267 | 10.136719 | 6.89296876 | 0.633544923 | 3.80127 | 53.21777 |
| Allahabad (M Corp.) WARD NO.-0019 | 16069 | 29147 | 11659 | 7928 | 3731 | 1306 | 10.446157 | 7.10338709 | 0.652884843 | 3.917309 | 54.84233 |
| Allahabad (M Corp.) WARD NO.-0020 | 11574 | 20993 | 8397 | 5710 | 2687 | 941 | 7.5240417 | 5.11634839 | 0.470252609 | 2.821516 | 39.50122 |
| Allahabad (M Corp.) | 1976 | 35847 | 14339 | 9750 | 4588 | 1606 | 12.84 | 8.736 | 0.8029 | 4.81 | 67.4 |

©IJRASET: All Rights are Reserved

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WARD NO.-0021 | 3 | | | | | | 7558 | 33948 | 72379 | 7834 | 4968 |
| Allahabad (M Corp.) WARD NO.-0022 | 11921 | 21623 | 8649 | 5881 | 2768 | 969 | 7.74962 | 5.269 74159 | 0.4843 51249 | 2.90 6107 | 40.6 855 |
| Allahabad (M Corp.) WARD NO.-0023 | 13581 | 24634 | 9854 | 6700 | 3153 | 1104 | 8.828 755 | 6.003 55343 | 0.5517 97191 | 3.31 0783 | 46.3 5096 |
| Allahabad (M Corp.) WARD NO.-0024 | 14126 | 25622 | 10249 | 6969 | 3280 | 1148 | 9.183 0494 | 6.244 47359 | 0.5739 40587 | 3.44 3644 | 48.2 1101 |
| Allahabad (M Corp.) WARD NO.-0025 | 19960 | 36204 | 14482 | 9848 | 4634 | 1622 | 12.97 5624 | 8.823 42438 | 0.8109 76506 | 4.86 5859 | 68.1 2203 |
| Allahabad (M Corp.) WARD NO.-0026 | 10671 | 19356 | 7742 | 5265 | 2478 | 867 | 6.937 0183 | 4.717 17242 | 0.4335 63642 | 2.60 1382 | 36.4 1935 |
| Allahabad (M Corp.) WARD NO.-0027 | 16122 | 29243 | 11697 | 7954 | 3743 | 1310 | 10.48 0612 | 7.126 81603 | 0.6550 38238 | 3.93 0229 | 55.0 2321 |
| Allahabad (M Corp.) WARD NO.-0028 | 9937 | 18024 | 7210 | 4903 | 2307 | 807 | 6.459 8585 | 4.392 70381 | 0.4037 41159 | 2.42 2447 | 33.9 1426 |
| Allahabad (M Corp.) WARD NO.-0029 | 12983 | 23549 | 9420 | 6405 | 3014 | 1055 | 8.440 0064 | 5.739 20435 | 0.5275 00399 | 3.16 5002 | 44.3 1003 |
| Allahabad (M Corp.) WARD NO.-0030 | 15799 | 28657 | 11463 | 7795 | 3668 | 1284 | 10.27 0636 | 6.984 03216 | 0.6419 1472 | 3.85 1488 | 53.9 2084 |
| Allahabad (M Corp.) WARD NO.-0031 | 9361 | 16979 | 6792 | 4618 | 2173 | 761 | 6.085 4117 | 4.138 07994 | 0.3803 3823 | 2.28 2029 | 31.9 4841 |
| Allahabad (M Corp.) WARD NO.-0032 | 20955 | 38009 | 15204 | 10338 | 4865 | 1703 | 13.62 2455 | 9.263 26944 | 0.8514 03441 | 5.10 8421 | 71.5 1789 |
| Allahabad (M Corp.) WARD NO.-0033 | 19527 | 35419 | 14168 | 9634 | 4534 | 1587 | 12.69 4139 | 8.632 01442 | 0.7933 83679 | 4.76 0302 | 66.6 4423 |
| Allahabad (M Corp.) WARD NO.-0034 | 15380 | 27897 | 11159 | 7588 | 3571 | 1250 | 9.998 2514 | 6.798 81097 | 0.6248 90714 | 3.74 9344 | 52.4 9082 |

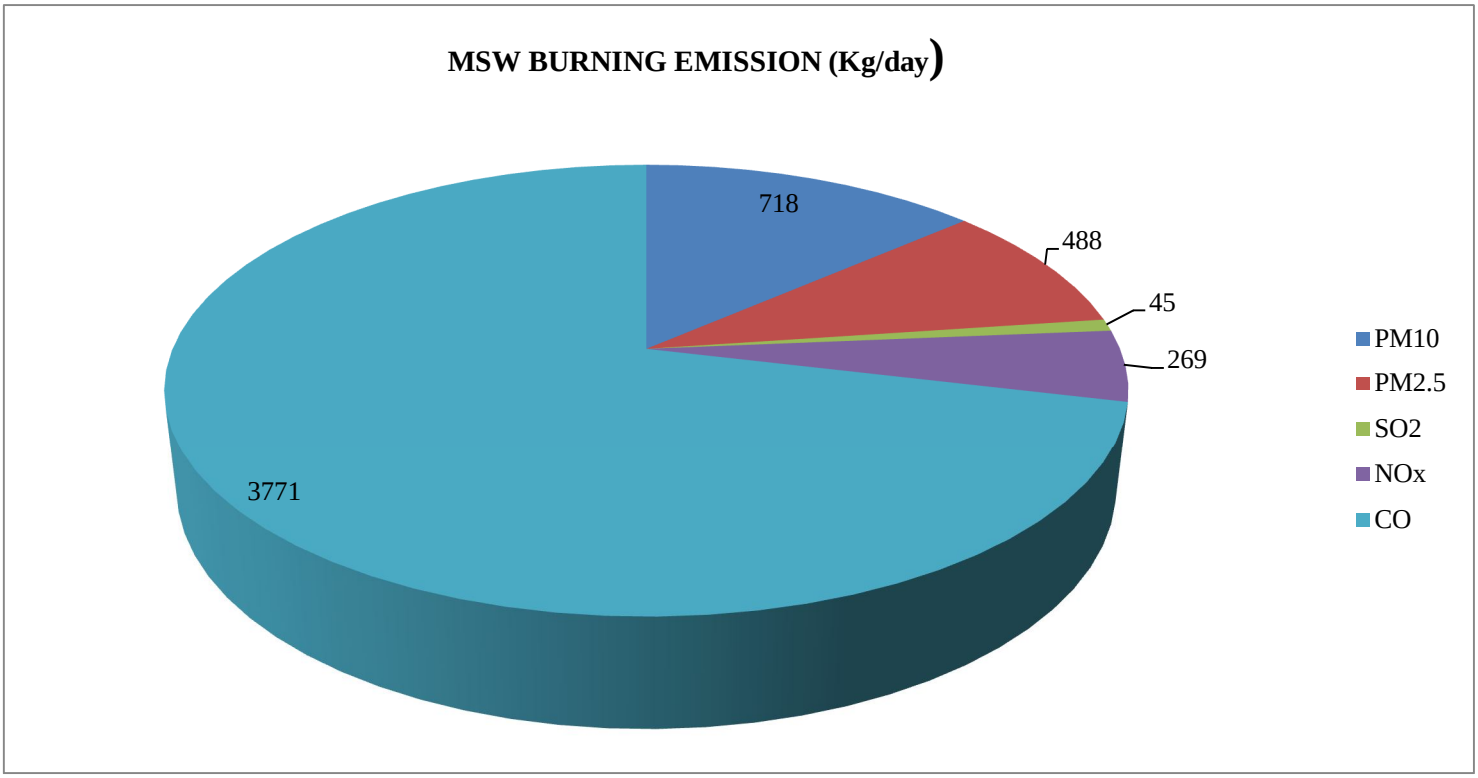



Fig:3- Pie chart shows emissions result

©IJRASET: All Rights are Reserved

Table:2- Grid-wise emissions (kg/day) of air pollutants

| Grid | Imoprtant Location | PM10 | PM2.5 | SO2 | NOx | CO |
|---|---|---|---|---|---|---|
| P3 | | 0.848194 | 0.576772 | 0.053012 | 0.318073 | 4.45302 |
| P4 | Mirakhpur kachhar | 1.087302 | 0.739366 | 0.067956 | 0.407738 | 5.708337 |
| P5 | Naini Railway Station | 39.57262 | 26.90938 | 2.473289 | 14.83973 | 207.7563 |
| P7 | | 0.996688 | 0.677748 | 0.062293 | 0.373758 | 5.232613 |
| P8 | | 0.024214 | 0.016466 | 0.001513 | 0.00908 | 0.127124 |
| P9 | Daiwghat | 88.61592 | 60.25883 | 5.538495 | 33.23097 | 465.2336 |
| P10 | Rani Mandi | 139.9353 | 95.15602 | 8.745957 | 52.47574 | 734.6604 |
| P11 | Bai Ka Bagh | 32.8471 | 22.33603 | 2.052944 | 12.31766 | 172.4473 |
| P12 | | 3.214236 | 2.185681 | 0.20089 | 1.205339 | 16.87474 |
| P13 | Bamrauli | 20.91206 | 14.2202 | 1.307004 | 7.842024 | 109.7883 |
| P14 | Transport nagar | 43.99292 | 29.91518 | 2.749557 | 16.49734 | 230.9628 |
| P15 | Lukarganj | 18.08347 | 12.29676 | 1.130217 | 6.781302 | 94.93823 |
| P16 | Johnstonganj | 69.87489 | 47.51492 | 4.367181 | 26.20308 | 366.8432 |
| P17 | Tagore Town | 80.98399 | 55.06911 | 5.061499 | 30.369 | 425.166 |
| P18 | Daraganj | 21.42509 | 14.56906 | 1.339068 | 8.03441 | 112.4817 |
| P21 | | 0.099215 | 0.067467 | 0.006201 | 0.037206 | 0.520881 |
| P22 | Muinabad | 45.81996 | 31.15758 | 2.863748 | 17.18249 | 240.5548 |
| P23 | Teliarganj | 36.62585 | 24.90558 | 2.289116 | 13.73469 | 192.2857 |
| P24 | | 15.07797 | 10.25302 | 0.942373 | 5.654238 | 79.15933 |
| P28 | | 2.101602 | 1.429089 | 0.13135 | 0.788101 | 11.03341 |
| P29 | Rasulabad | 37.98103 | 25.8271 | 2.373815 | 14.24289 | 199.4004 |
| P30 | | 0.384593 | 0.261523 | 0.024037 | 0.144222 | 2.019113 |
| P34 | | 0.170662 | 0.11605 | 0.010666 | 0.063998 | 0.895976 |
| P35 | Phaphaman | 11.22725 | 7.634527 | 0.701703 | 4.210217 | 58.94304 |

The spatial distribution map will show the most affected grids due to air pollutants emission. The following maps will represent the emission value for each pollutant.

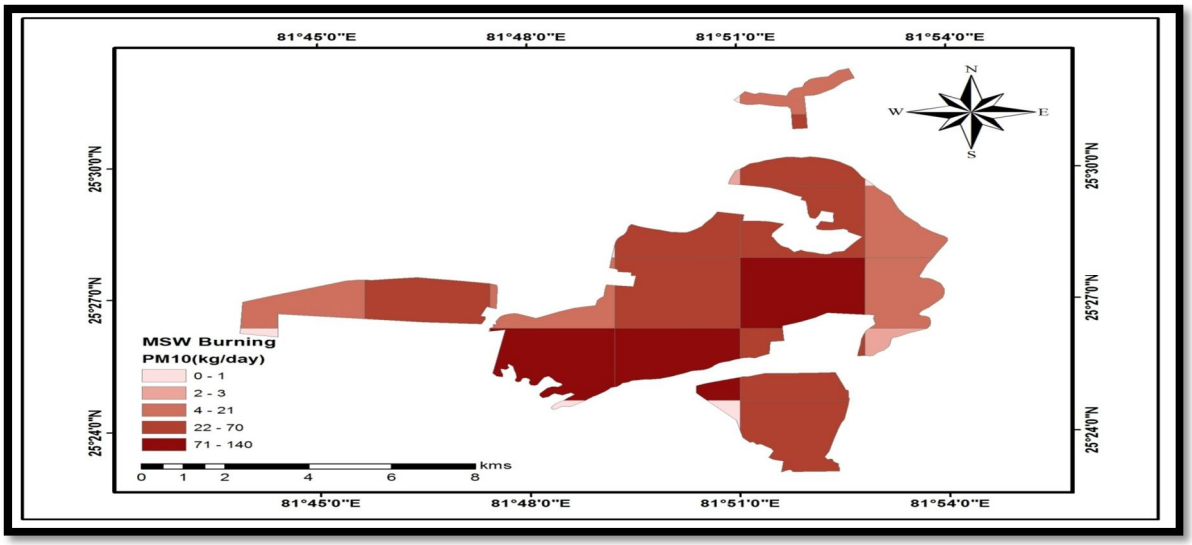



Fig:4- MSW spatial map for PM10 emission

©IJRASET: All Rights are Reserved

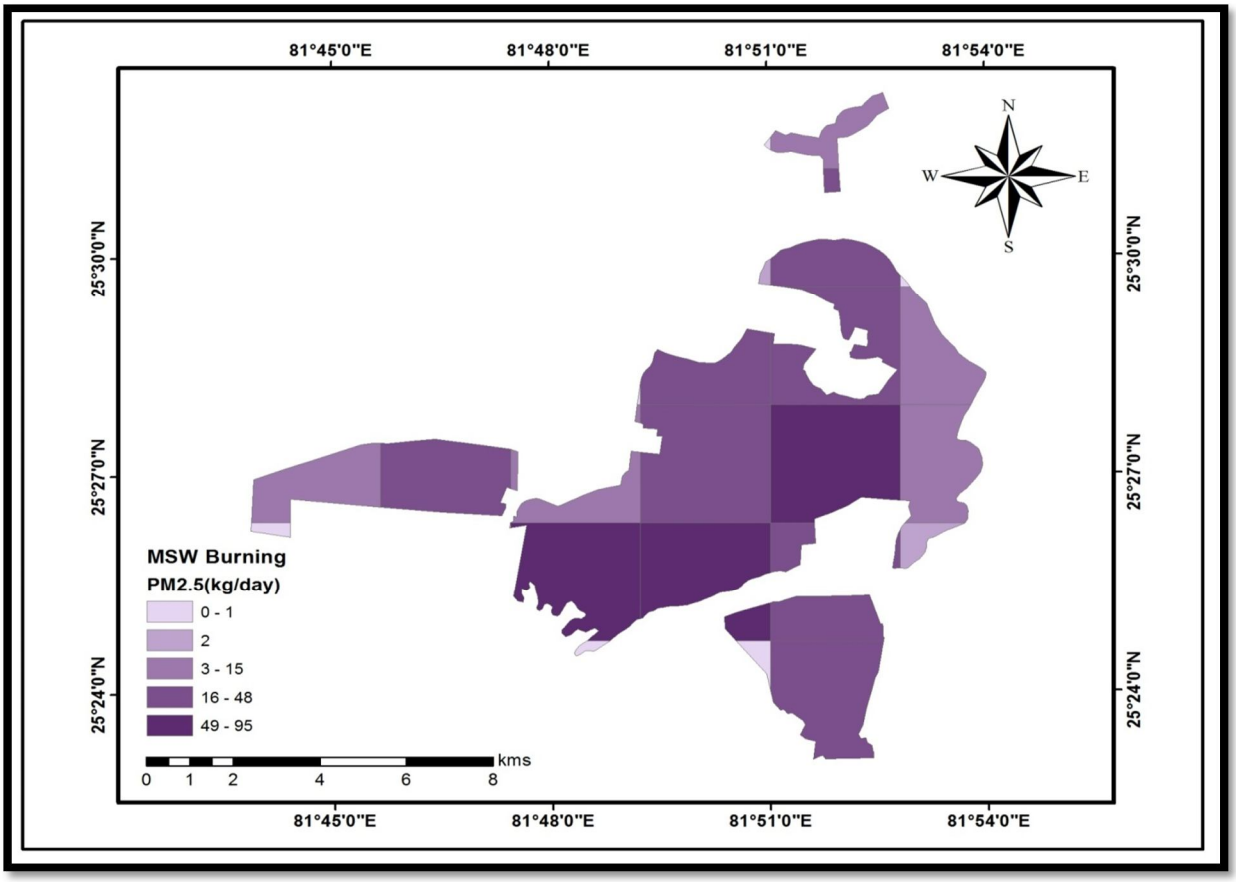



Fig:5- MSW spatial map for PM2.5 emission

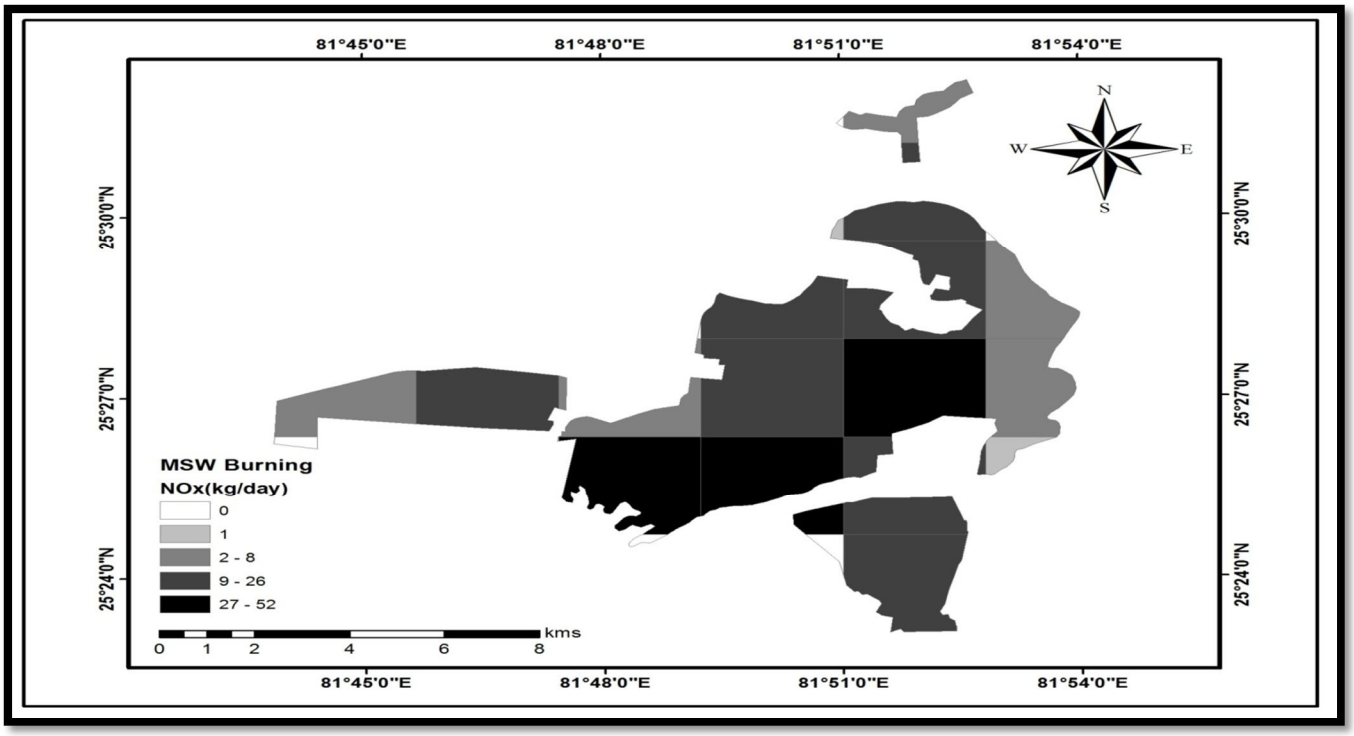



Fig:6- MSW spatial map for $NO_X$ emission

©IJRASET: All Rights are Reserved

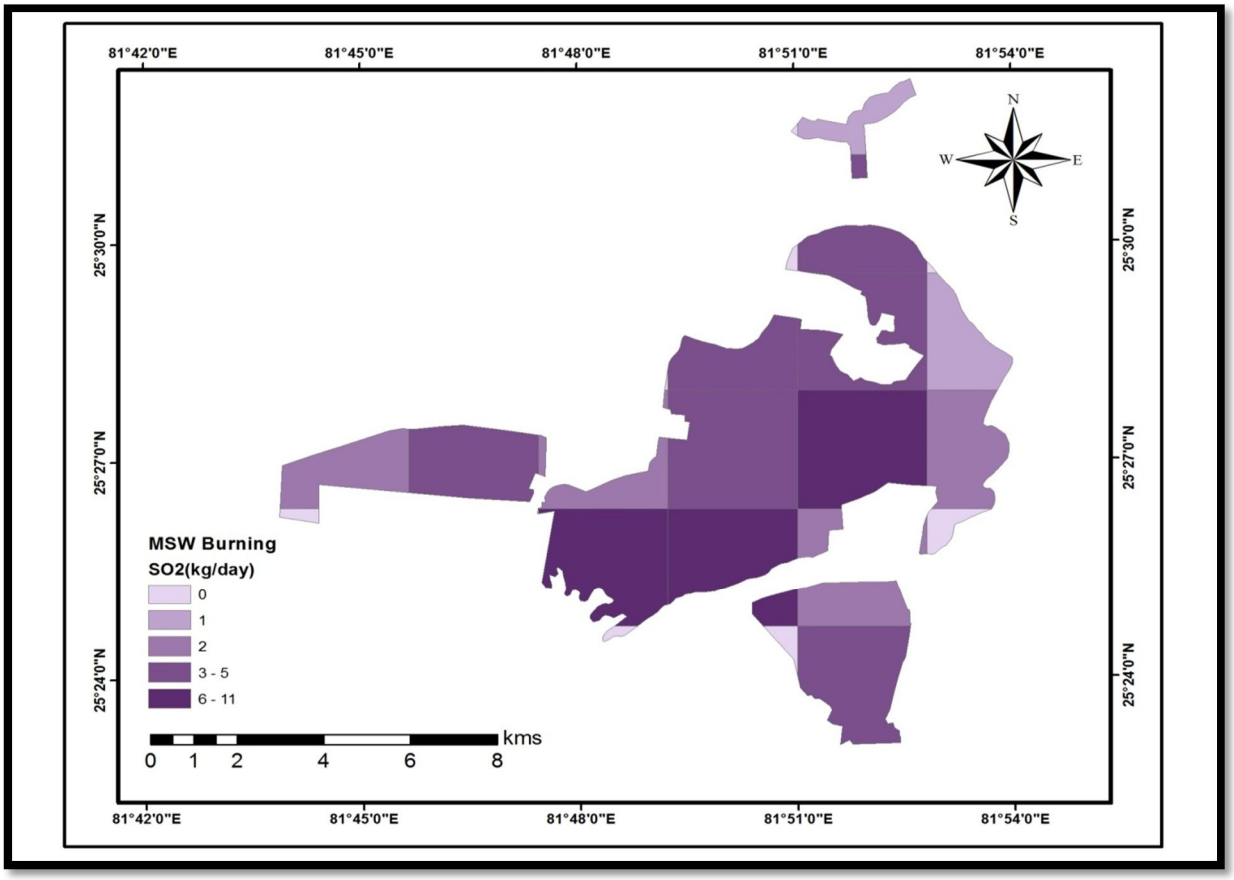



Fig:7- MSW spatial map for $SO_2$emission

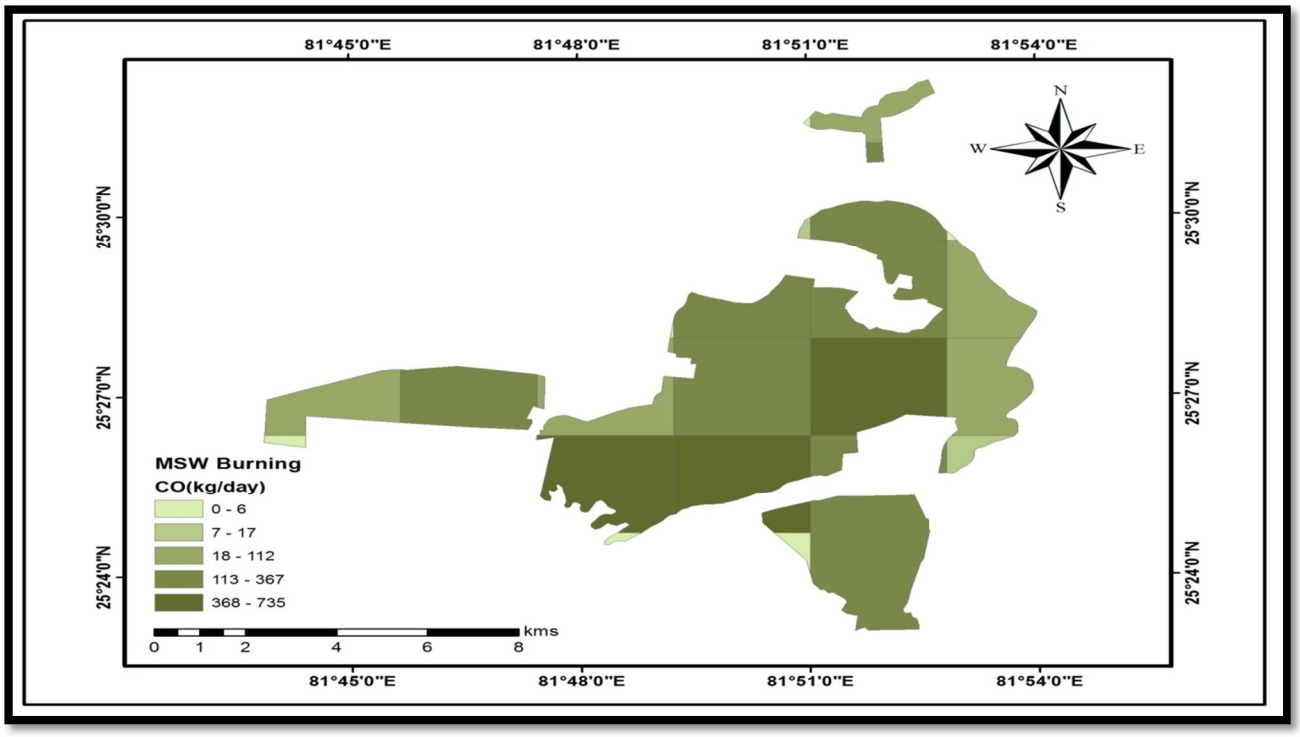



Fig:8- MSW spatial map for CO emission

©IJRASET: All Rights are Reserved

## V. CONCLUSION

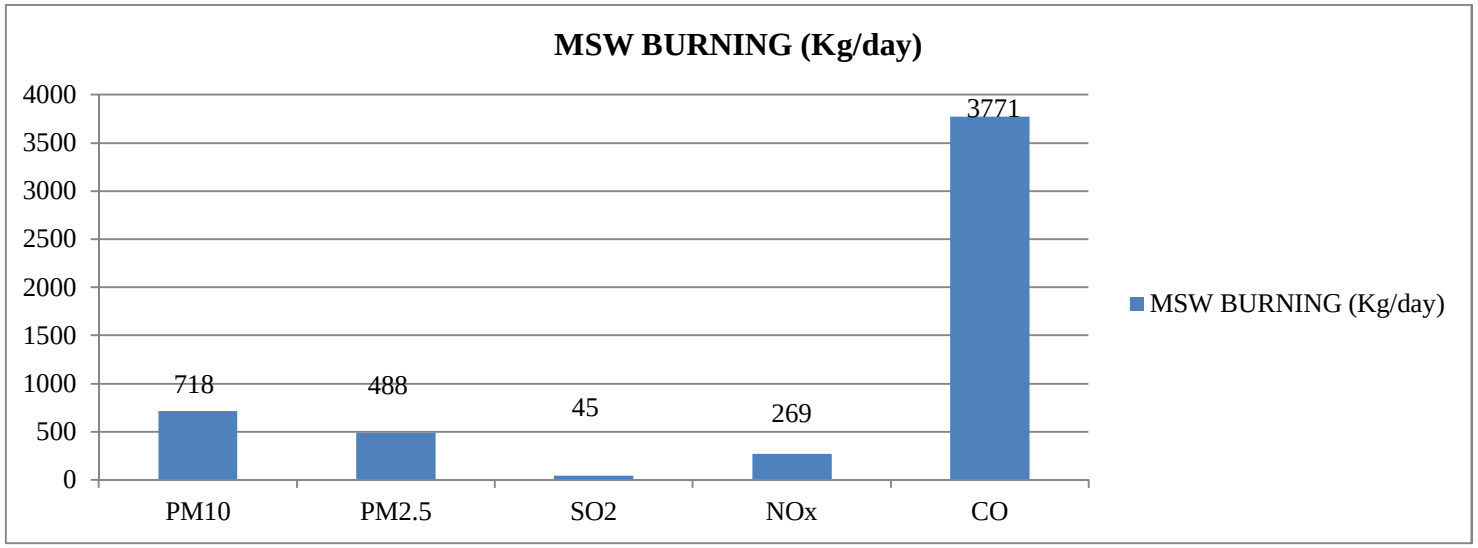



Fig:9- Final emissions (kg/day) from burning solid waste

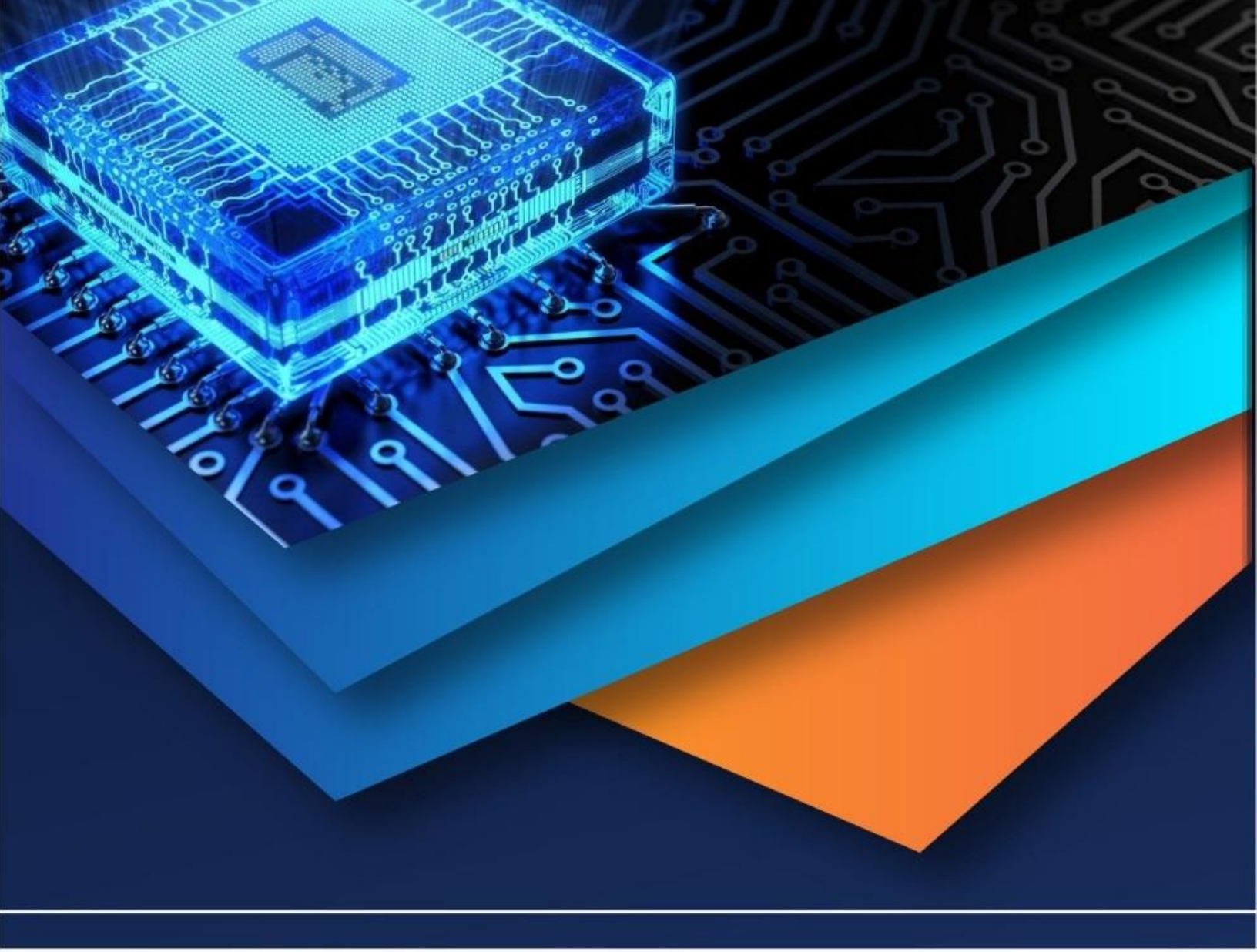
| (Domestic)PM10 | | |
|---|---|---|
| High Emission Grid | LOCATION | EMISSIONS(Kg/day) |
| P5 | Naini railway station | 142 |
| P9 | Daiwghat | 164 |
| P10 | Ranimandi | 292 |
| (Domestic)PM2.5 | | |
| High Emission Grid | LOCATION | EMISSIONS(Kg/day) |
| P5 | Naini railway station | 99 |
| P9 | Daiwghat | 115 |
| P10 | Ranimandi | 204 |
| P14 | SukmSarai | 117 |
| P17 | Tagore Town | 101 |
| P29 | Rasulabad | 62 |

Table:3- Grids with high emission value of $PM_{10}$ and $PM_{2.5}$

## REFERENCES

[1] Azliyana Azhari a,b, Nor Diana Abdul Halim c, Murnira Othman,Highly spatially resolved emission inventory of selected air pollutants in Kuala Lumpur's urban environment, 12 October 2020 1309-1042/2020.
[2] Vijai Krishna, Sadhana Chaurasia, Aspects of Municipal Solid Waste Management in Allahabad City: A Questioner Survey of the Citizens, Volume 11, Issue 2 Ver. I (Feb. 2017)
[3] Hossein Shahbazi, Sina Taghvaee, A GIS based emission inventory development for Tehran Urban Climate 17 (2016) 216–229
[4] CRISIL report, City Development Plan for Allahabad 2041, March 2015, http://allahabadmc.gov.in/documentslist/City_Development_Plan_Allahabad-2041.pdf
[5] Planning Commission Report, May 12,2014 https://niti.gov.in/planningcommission.gov.in/docs/reports/genrep/rep_energyvol2.pdf
[6] Government of India Swach Bharat Mission Municipal Solid Waste Management Plan Manual 2016 http://cpheeo.gov.in/upload/uploadfiles/files/Part2.pdf
[7] "Census of India 2011" https://censusindia.gov.in/pca/Searchdata.aspx
[8] Nmcg final report, Environmental and Social Assessment with management Plan for Sewage works in Sewage District 'A' of Allahabad City, Uttar Pradesh https://www.nmcg.nic.in/writereaddata/fileupload/27_FinalESAMPAllahabad%20A.pdf

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)