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

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**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. PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, 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<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, 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<sup>2</sup> area. The spatial distribution plotted for Prayagraj city shows the hotspot grid areas for all 5 air pollutants emission. The hotspot grids for PM<sub>10</sub> are P9, P10, P17, P29 and for PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, are P9, P10, P17 and for CO are P9, P10, P14, P17, P29.*

**Keywords:** *PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, 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<sup>2</sup> grid area are digitised using ARC-GIS.

## II. STUDY AREA

Prayagraj, 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 km<sup>2</sup> 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.

### 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

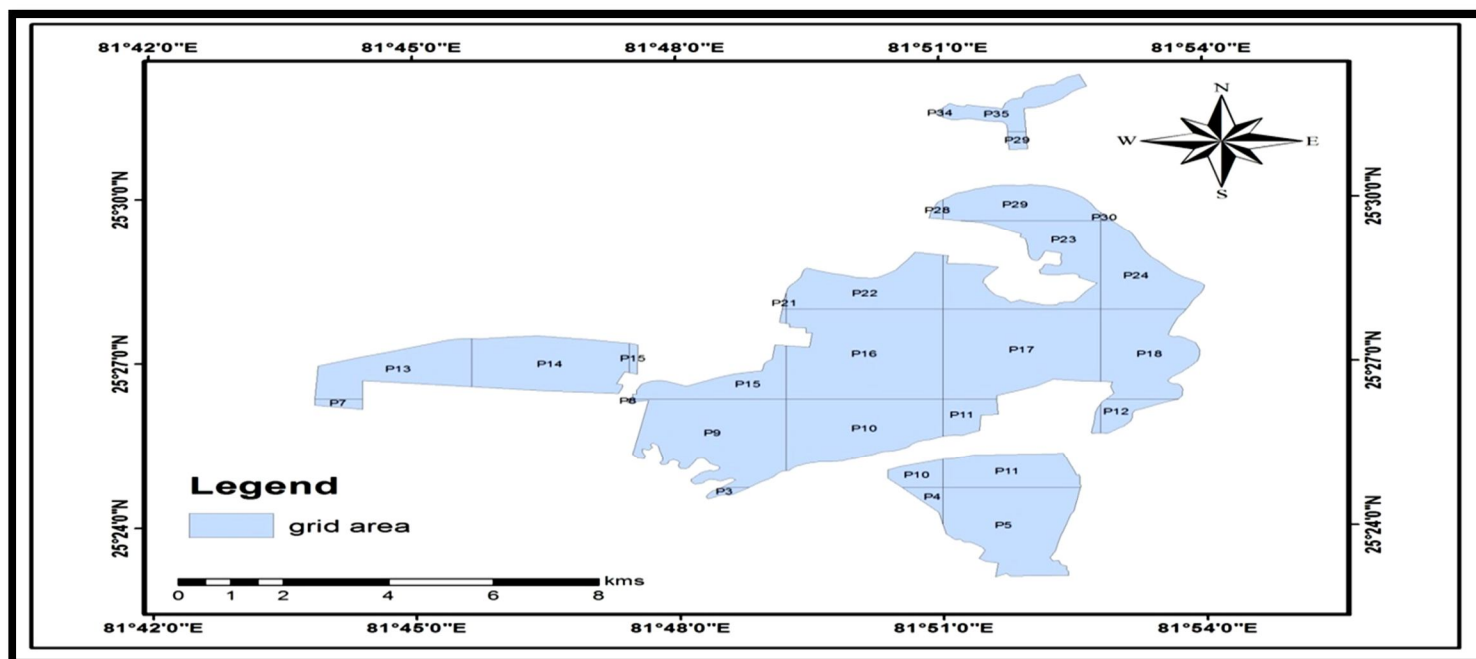
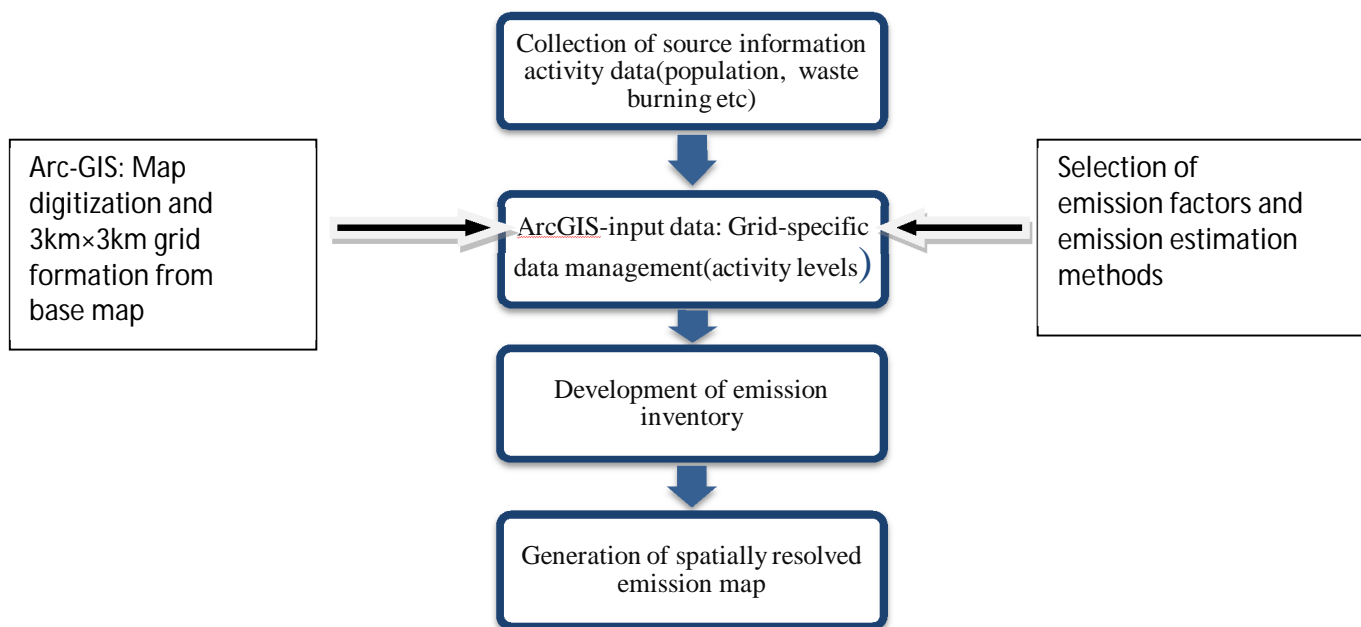


Fig:1- Digitised grid map using ARC-GIS

C. Formula and Emission Factors used

1) The emission factors table given below which are used calculating emission for pollutants PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, CO

Pollutants	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>2</sub>	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 –

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

P<sub>n</sub>= population after n<sup>th</sup> 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<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, 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.

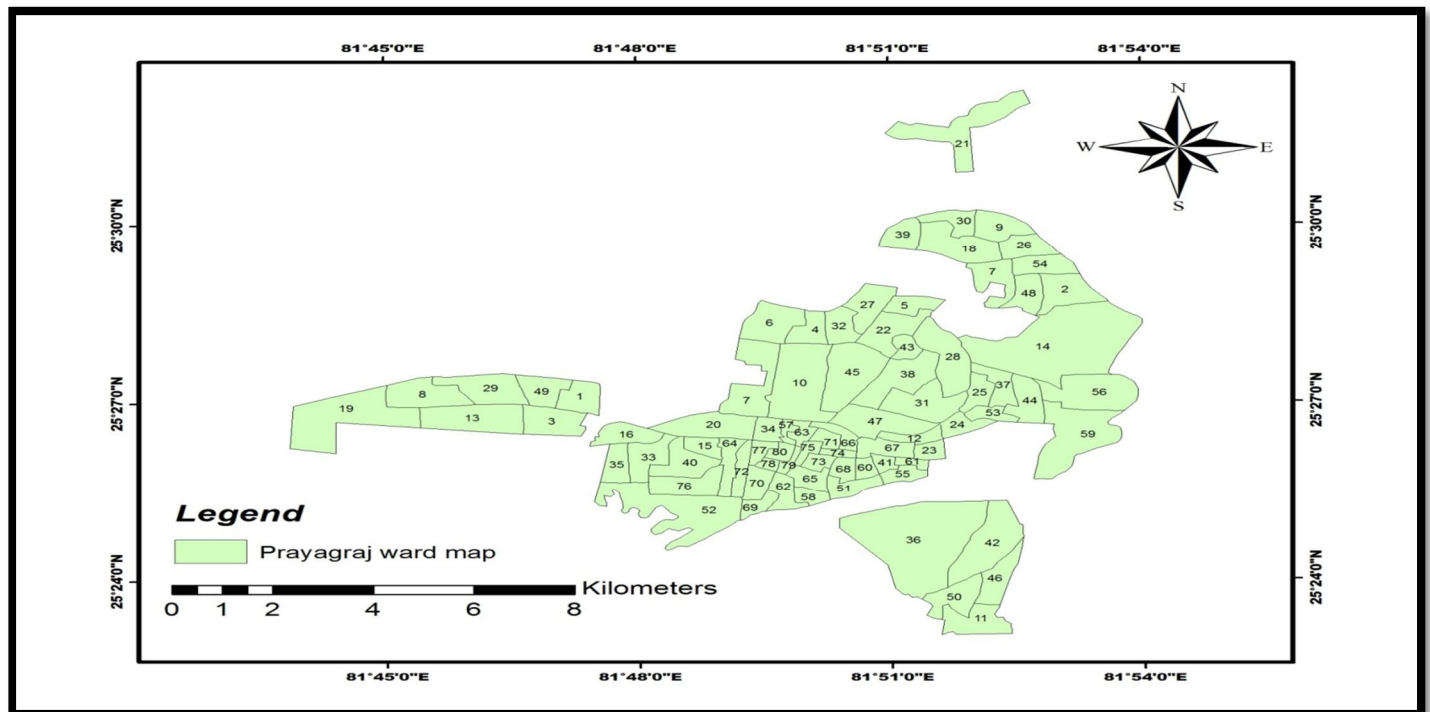


Fig-2: Digitised Prayagraj ward map using ARC-GIS

**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	Popul ation	new populati on	Waste Generation (kg/day)	Waste collectio n	UNCOLL ETCTED	DRY WAST E	PM1	PM2.5	SO2	NOx	CO
							0	5.44	0.5	3	42
		2017980 .259									
Allahabad (M Corp.) WARD NO.-0001	1765 4	32022	12809	8710	4099	820	6.558 0208	4.459 45417	0.4098 76302	2.45 9258	34.4 2961
Allahabad (M Corp.) WARD NO.-0002	1212 5	21993	8797	5982	2815	985	7.882 2366	5.359 92087	0.4926 39786	2.95 5839	41.3 8174
Allahabad (M Corp.) WARD NO.-0003	1521 1	27590	11036	7505	3532	1236	9.888 3877	6.724 10362	0.6180 2423	3.70 8145	51.9 1404
Allahabad (M Corp.) WARD NO.-0004	1405 6	25495	10198	6935	3263	1142	9.137 5437	6.213 52972	0.5710 96481	3.42 6579	47.9 721
Allahabad (M Corp.) WARD NO.-0005	1543 6	27998	11199	7616	3584	1254	10.03 4656	6.823 56607	0.6271 65999	3.76 2996	52.6 8194
Allahabad (M Corp.) WARD NO.-0006	1153 2	20917	8367	5689	2677	937	7.496 7383	5.097 78206	0.4685 46145	2.81 1277	39.3 5788
Allahabad (M Corp.) WARD NO.-0007	6750	12243	4897	3330	1567	549	4.388 0492	2.983 87348	0.2742 53077	1.64 5518	23.0 3726
Allahabad (M Corp.) WARD NO.-0008	2036 0	36930	14772	10045	4727	1654	13.23 5657	9.000 24651	0.8272 2854	4.96 3371	69.4 872
Allahabad (M Corp.) WARD NO.-0009	1220 6	22140	8856	6022	2834	992	7.934 8932	5.395 72736	0.4959 30823	2.97 5585	41.6 5819
Allahabad (M Corp.) WARD NO.-0010	1660 0	30110	12044	8190	3854	1349	10.79 1351	7.338 11847	0.6744 59419	4.04 6757	56.6 5459
Allahabad (M Corp.) WARD NO.-0011	1365 4	24766	9906	6736	3170	1110	8.876 211	6.035 82347	0.5547 63187	3.32 8579	46.6 0011
Allahabad (M Corp.) WARD NO.-0012	1219 6	22122	8849	6017	2832	991	7.928 3924	5.391 3068	0.4955 24522	2.97 3147	41.6 2406
Allahabad (M Corp.) WARD NO.-0013	1337 5	24260	9704	6599	3105	1087	8.694 8383	5.912 49004	0.5434 27393	3.26 0564	45.6 479
Allahabad (M Corp.) WARD NO.-0014	1416 3	25689	10276	6988	3288	1151	9.207 1024	6.260 82964	0.5754 439	3.45 2663	48.3 3729
Allahabad (M Corp.) WARD NO.-0015	8681	15746	6298	4283	2015	705	5.643 3563	3.837 48232	0.3527 09772	2.11 6259	29.6 2762
Allahabad (M Corp.) WARD NO.-0016	9540	17304	6922	4707	2215	775	6.201 7762	4.217 20785	0.3876 11015	2.32 5666	32.5 5933
Allahabad (M Corp.) WARD NO.-0017	1663 1	30166	12066	8205	3861	1351	10.81 1503	7.351 82219	0.6757 18951	4.05 4314	56.7 6039
Allahabad (M Corp.) WARD NO.-0018	1559 3	28283	11313	7693	3620	1267	10.13 6719	6.892 96876	0.6335 44923	3.80 127	53.2 1777
Allahabad (M Corp.) WARD NO.-0019	1606 9	29147	11659	7928	3731	1306	10.44 6157	7.103 38709	0.6528 84843	3.91 7309	54.8 4233
Allahabad (M Corp.) WARD NO.-0020	1157 4	20993	8397	5710	2687	941	7.524 0417	5.116 34839	0.4702 52609	2.82 1516	39.5 0122
Allahabad (M Corp.)	1976	35847	14339	9750	4588	1606	12.84	8.736	0.8029	4.81	67.4

WARD NO.-0021	3						7558	33948	72379	7834	4968
Allahabad (M Corp.)	1192	21623	8649	5881	2768	969	7.749	5.269	0.4843	2.90	40.6
WARD NO.-0022	1						62	74159	51249	6107	855
Allahabad (M Corp.)	1358	24634	9854	6700	3153	1104	8.828	6.003	0.5517	3.31	46.3
WARD NO.-0023	1						755	55343	97191	0783	5096
Allahabad (M Corp.)	1412	25622	10249	6969	3280	1148	9.183	6.244	0.5739	3.44	48.2
WARD NO.-0024	6						0494	47359	40587	3644	1101
Allahabad (M Corp.)	1996	36204	14482	9848	4634	1622	12.97	8.823	0.8109	4.86	68.1
WARD NO.-0025	0						5624	42438	76506	5859	2203
Allahabad (M Corp.)	1067	19356	7742	5265	2478	867	6.937	4.717	0.4335	2.60	36.4
WARD NO.-0026	1						0183	17242	63642	1382	1935
Allahabad (M Corp.)	1612	29243	11697	7954	3743	1310	10.48	7.126	0.6550	3.93	55.0
WARD NO.-0027	2						0612	81603	38238	0229	2321
Allahabad (M Corp.)	9937	18024	7210	4903	2307	807	6.459	4.392	0.4037	2.42	33.9
WARD NO.-0028							8585	70381	41159	2447	1426
Allahabad (M Corp.)	1298	23549	9420	6405	3014	1055	8.440	5.739	0.5275	3.16	44.3
WARD NO.-0029	3						0064	20435	00399	5002	1003
Allahabad (M Corp.)	1579	28657	11463	7795	3668	1284	10.27	6.984	0.6419	3.85	53.9
WARD NO.-0030	9						0636	03216	1472	1488	2084
Allahabad (M Corp.)	9361	16979	6792	4618	2173	761	6.085	4.138	0.3803	2.28	31.9
WARD NO.-0031							4117	07994	3823	2029	4841
Allahabad (M Corp.)	2095	38009	15204	10338	4865	1703	13.62	9.263	0.8514	5.10	71.5
WARD NO.-0032	5						2455	26944	03441	8421	1789
Allahabad (M Corp.)	1952	35419	14168	9634	4534	1587	12.69	8.632	0.7933	4.76	66.6
WARD NO.-0033	7						4139	01442	83679	0302	4423
Allahabad (M Corp.)	1538	27897	11159	7588	3571	1250	9.998	6.798	0.6248	3.74	52.4
WARD NO.-0034	0						2514	81097	90714	9344	9082

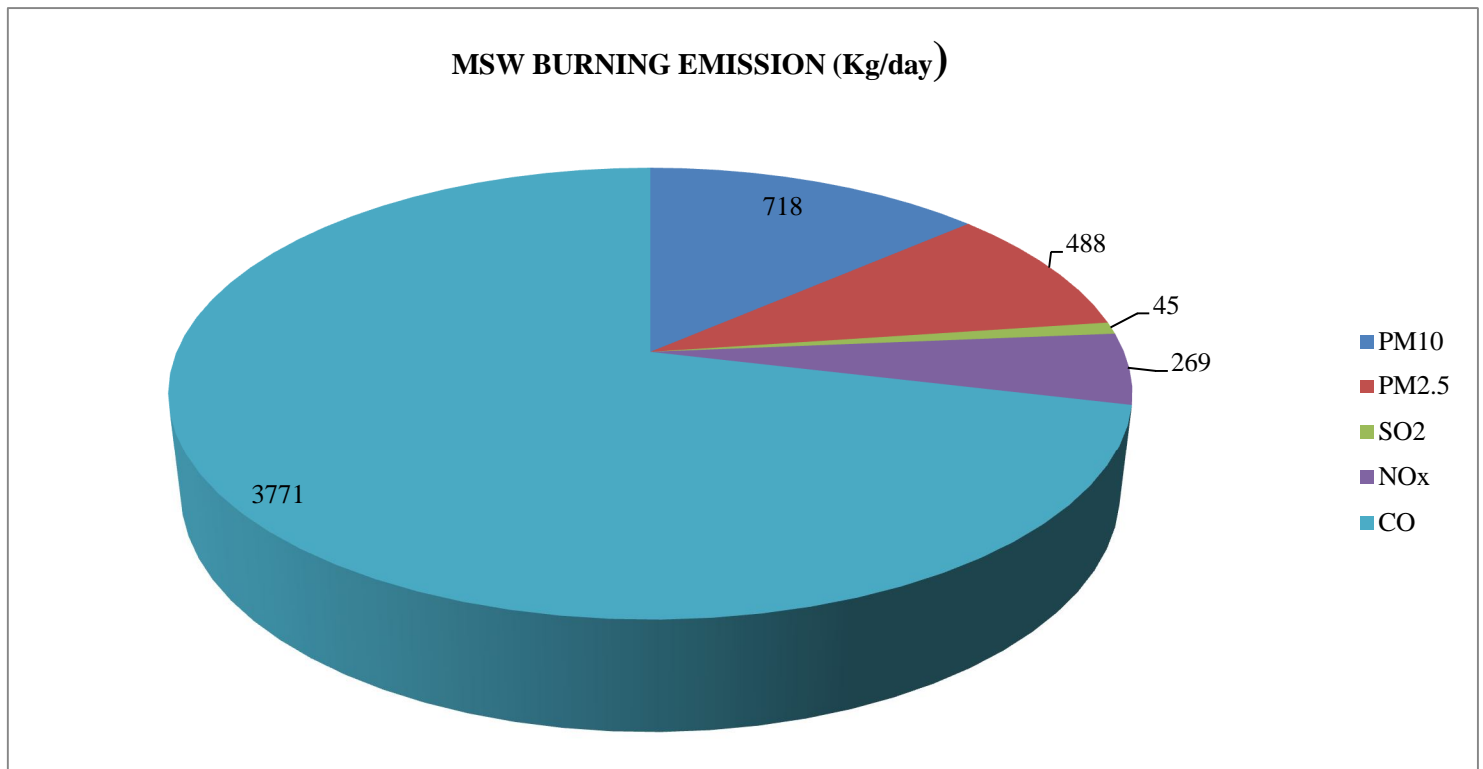


Fig:3- Pie chart shows emissions result

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

Grid	Important 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.

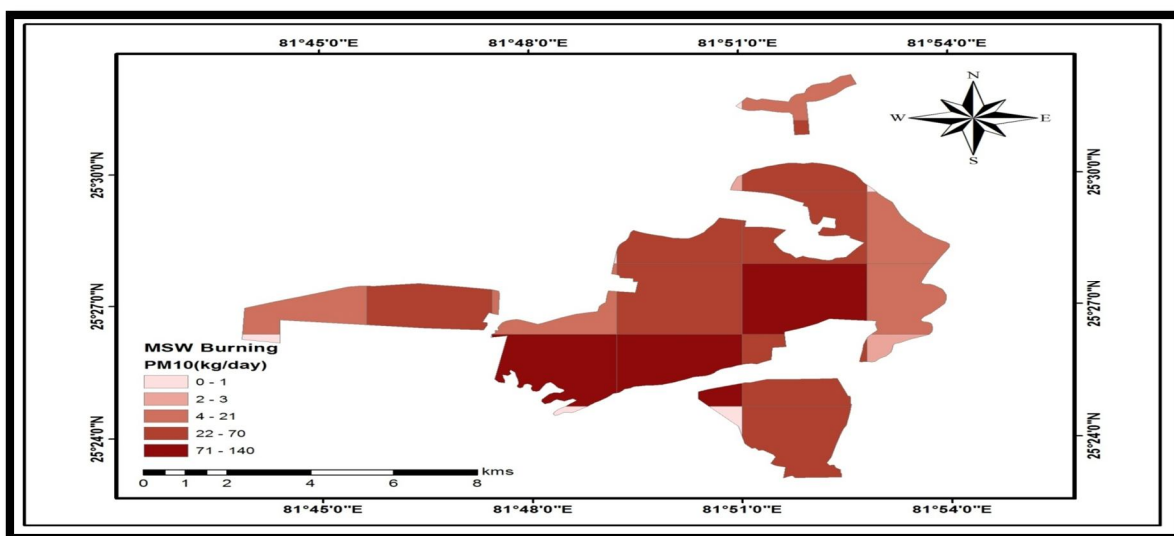


Fig:4- MSW spatial map for PM10 emission

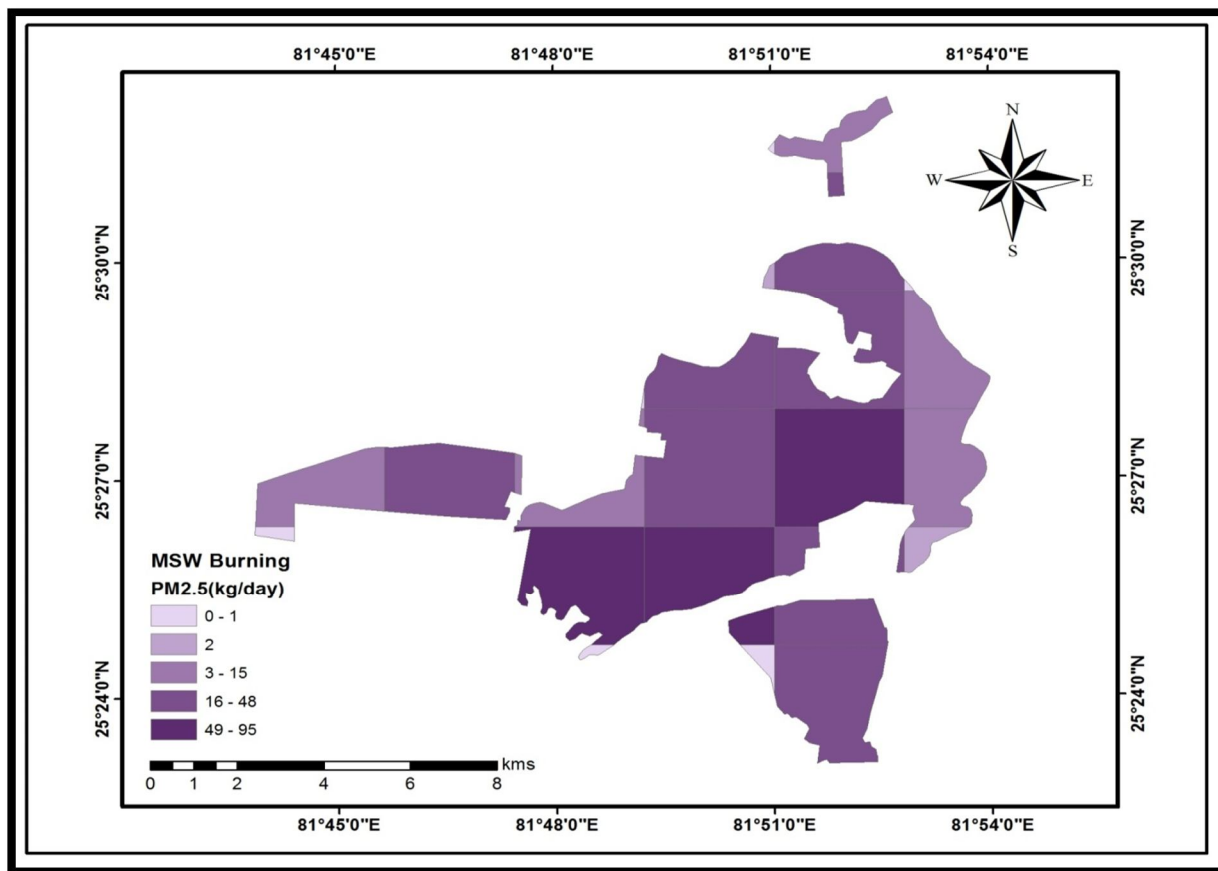


Fig:5- MSW spatial map for PM2.5 emission

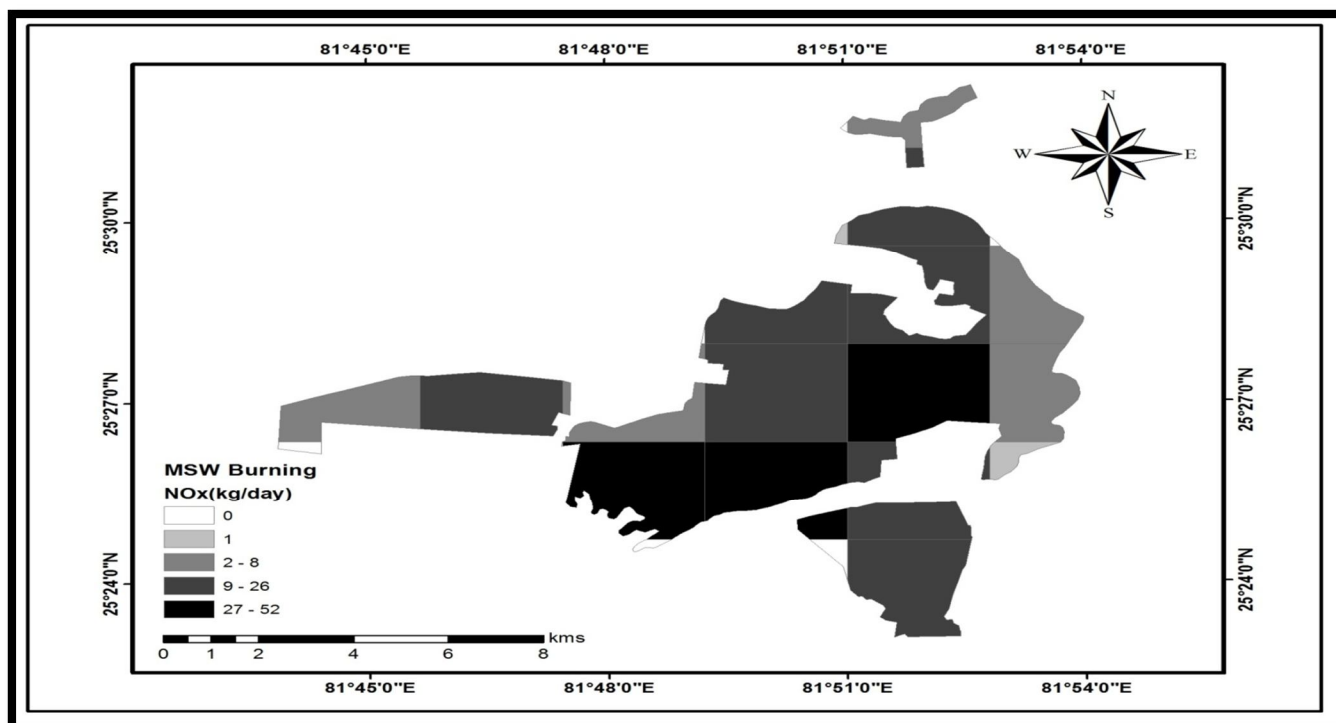


Fig:6- MSW spatial map for NO<sub>x</sub> emission



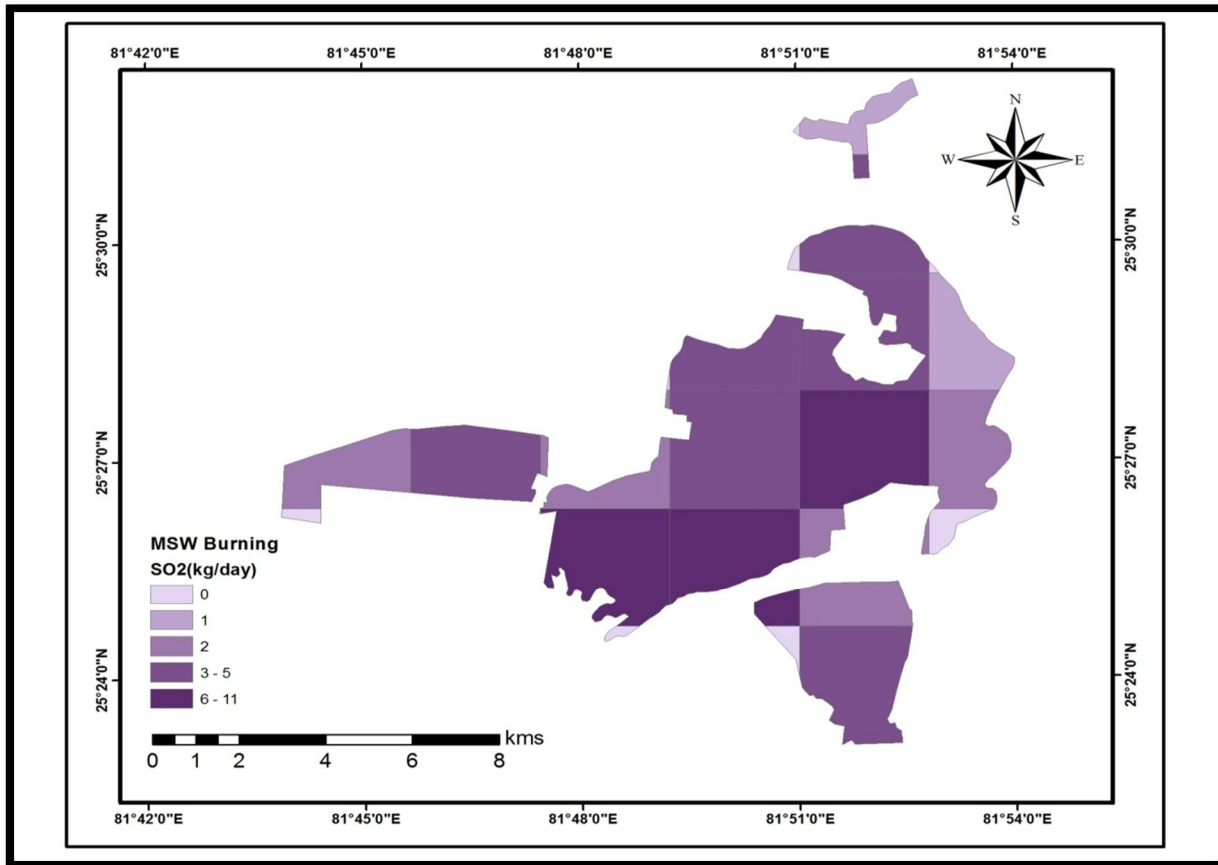


Fig:7- MSW spatial map for SO<sub>2</sub>emission

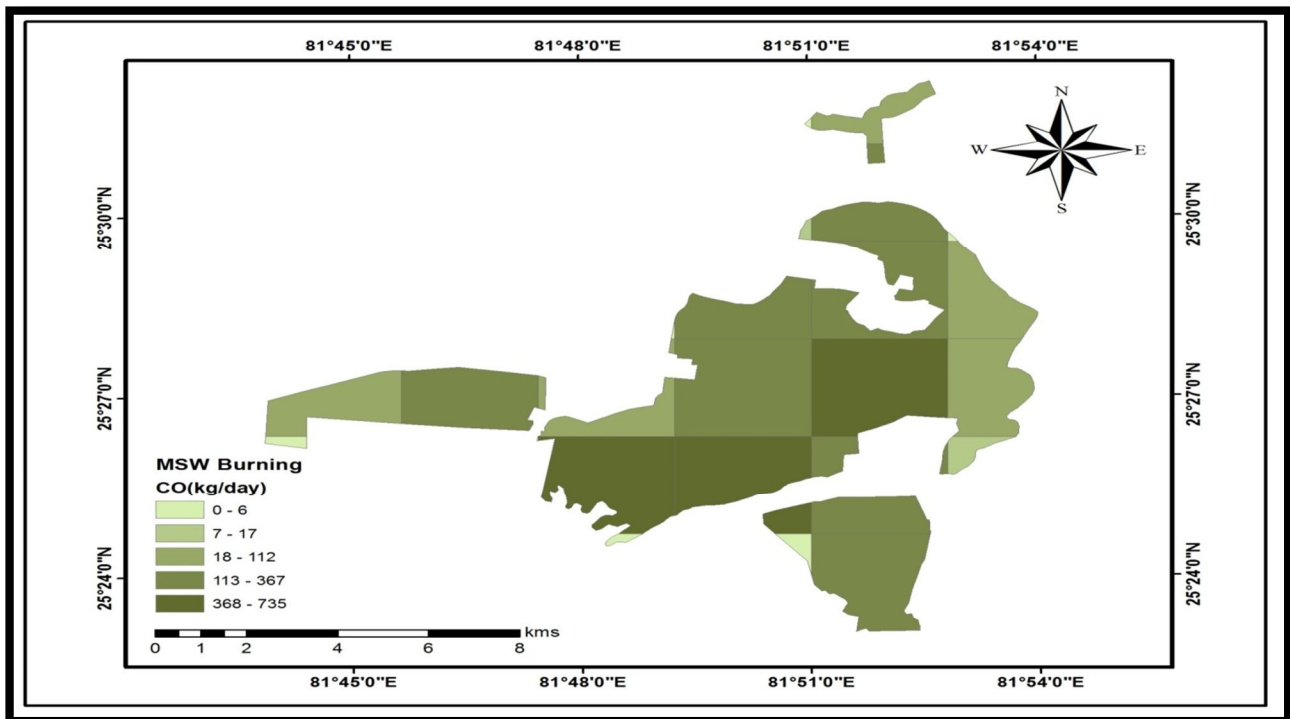


Fig:8- MSW spatial map for CO emission

### V. CONCLUSION

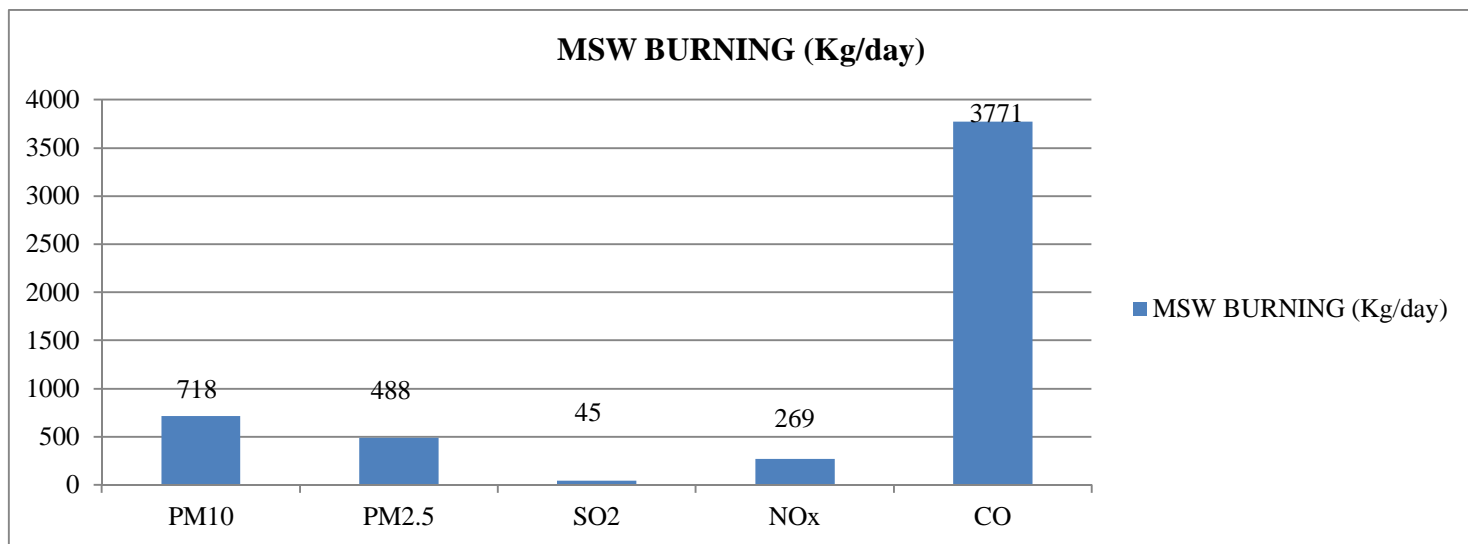


Fig:9- Final emissions (kg/day) from burning solid waste

(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<sub>10</sub> and PM<sub>2.5</sub>

### 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 Taghvaei, 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](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](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](https://www.nmcg.nic.in/writereaddata/fileupload/27_FinalESAMPAllahabad%20A.pdf)



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