International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
"International Conference on Modern Trends in Civil Engineering"(ICMTCE-2019)
(Towards Sustainable Development Goals)
Volume 5, Special Issue 02, Feb.-2019

CARBON FOOTPRINT OF MUNICIPAL SOLID WASTE: A CASE STUDY OF LUCKNOW

Ankit Kumar[1], Avneesh Tiwari[2], Tauqeer Alam[3], A.K. Shukla[4]

[1]*M.Tech , Environmental Engineering, Institute of Engineering and Technology, Lucknow,*
[2]*M.Tech , Environmental Engineering, Institute of Engineering and Technology, Lucknow,*
[3]*M.Tech , Environmental Engineering, Institute of Engineering and Technology, Lucknow,*
[4]*Professor Civil Engineering Department, Institute of Engineering and Technology, Lucknow.*

Abstract-Carbon footprint refers to the direct or indirect emissions of carbon dioxide and other greenhouse gases expressed in terms of carbon dioxide equivalent. Municipal solid waste consists of organic and inorganic materials. Decomposition of organic waste leads to the formation of potent greenhouse gases (GHGs) like methane and carbon dioxide. The objective of this study is to estimate the carbon footprint of Lucknow subjected to the total organic waste generated. The city had observed population growth rate of 2.6% per year from 2001 to 2011 which has resulted in the increase of waste. Every day approximately 4000-5000 tonnes of organic waste is generated in the city. Population forecasting is done to estimate the population and the amount of waste generated in the city by considering the previous growth rate. Emission factors are used for estimating the GHGs emission from the waste. The result obtained from the study reveals that the emissions of carbon dioxide and methane is 745.22 kg/day and 58.71 kg/day respectively which accounts to the carbon footprint of 1978.1 kg/day in terms of equivalent carbon dioxide. Since carbon dioxide and methane are GHGs these emissions lead to increase in their concentration in the atmosphere which is responsible for global warming and climate change.

Keywords: Carbon Footprint, Carbon dioxide, Emission Factor, Greenhouse gases, Organic waste

INTRODUCTION

The world is getting hotter. According to a temperature analysis conducted by scientists at the National Aeronautics and Space Administration (NASA), Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by about 0.8° Celsius (1.4° Fahrenheit) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20°C per decade. Though these numbers appears to be small, but it has caused a significant impact on the environment. Increase in concentration of greenhouse gases (GHGs) in the atmosphere is one of the major reason for the rise in temperature as it absorbs the heat.

Carbon footprint (CF) refers to the direct or indirect emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) expressed in terms of carbon dioxide equivalents [1]. GHGs get into the air either because of natural sources or anthropogenic exercises. The contribution from natural sources is negligible and is killed because of the normal ecological processes, yet a substantial amount is created from anthropogenic sources, which is aggregating in the atmosphere.

With the development of a country and increase in population in a society the generation of solid waste have also increased. Although various technologies and waste management techniques have been developed to deal with the waste generated but still open burning and disposal of waste on land is a common practice. Municipal solid waste plays an important role in carbon footprint of a city. Poor management of municipal solid waste leads to the formation of GHGs like methane and carbon dioxide which escapes into the atmosphere. Methane has a global warming potential of 25 times over carbon dioxide for 100 year time horizon [2]. Therefore it becomes necessary to keep track of these emissions.

Study Area

This study is carried out in Lucknow, capital of Uttar Pradesh. It is located at 26°51' north & 80°57' east. It has a population of 2,902,900 (Census of India 2011) and is the eleventh most populous city of India. Due to the urbanization there is an average increase in population at the rate of 3.22% per year from 1971 to 2011. It is divided into 6 zones consisting 110 administrative wards.

Municipal Solid Waste Management & Composition

Lucknow Municipal Corporation is the governing authority for the management of waste in the city. Gurugram based firm Eco Green is assigned the duty to collect & manage the waste. In well organized society the collection of waste is done door

to door through e-rickshaws on daily basis whereas in some societies the waste is dumped at a common point near the streets which is collected once or twice a week leading to breeding of flies and a threat to health.

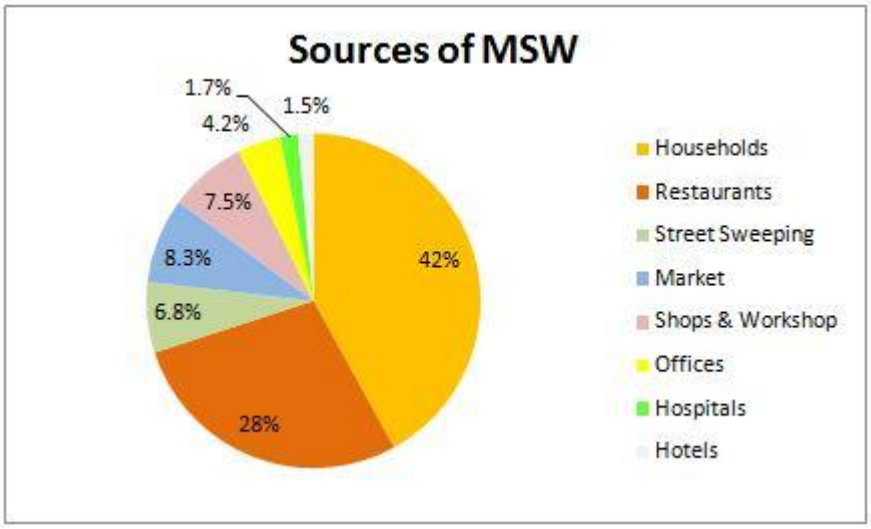

Figure 1: Sources of MSW (Rahul et al. 2013)

Municipal Solid Waste (MSW) commonly known as garbage or trash consists of daily items that we use and throw away, such as product packaging material, grass clippings, furniture, appliances, bottles, food scraps, newspapers, clothing, paint, and batteries. The pie chart given in Figure 1 shows the sources of these items in the city.
The total waste estimated to be generated in Lucknow in 2009 was 5245 tons per day and in 2012 it was 5890 tons per day. Total organic waste generated was 2522 tons per day in 2004, 3407 tons per day in 2008, 3726 tons per day in 2010 [3]. Since the degradation of organic waste is responsible for the emission of GHGs therefore only the organic waste is used for the carbon footprint estimation.

METHODOLOGY

The emission factors used for the calculation are based on the experimental result from the study done by T.V. Ramachandra *et al*. 2014. Emission factor used for the emission of CH_4 is 0.013 gm/kg & for CO_2 it is 0.165 gm/kg. Population forecasting method is used to estimate the population of the city [4]. The population growth rate of 2.6% per year as observed from 2001 to 2011 is used for estimating the population (Census of India). Figure 2 represents the yearly growth of population from 2011 to 2018.

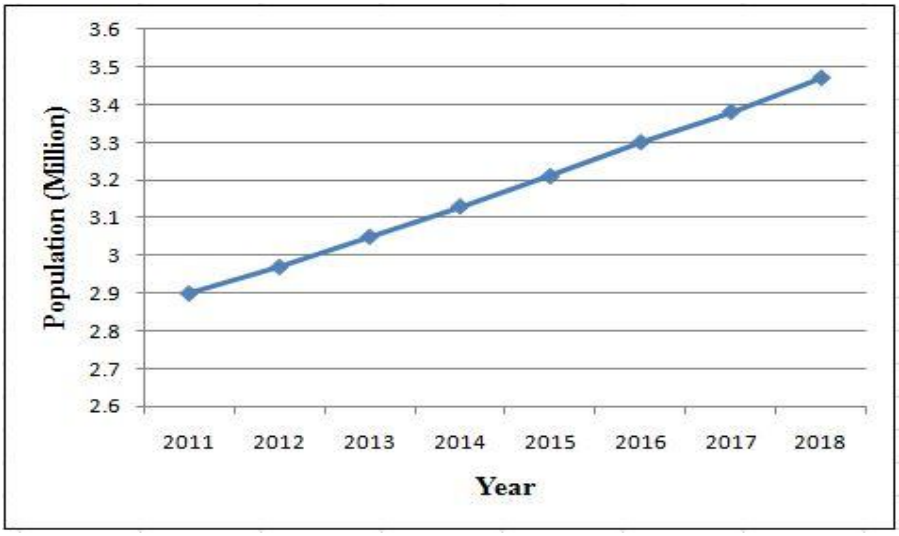

Figure 2: Growth of population

A study conducted by Rahul *et al*. 2013 on solid waste management and characteristics in Lucknow shows that the total organic waste generation was 2522 tons/day, 3407 tons/day and 3726 tons/day for 2004, 2008 and 2010 respectively [3]. This data is used to estimate the per capita generation of organic waste in the city.

CO_2 emission (gm/day) = W (kg/day) × 0.013 (gm/kg) (1)
CH_4 emission (gm/day) = W (kg/day) × 0.165 (gm/kg) (2)
Where
W = Total organic waste generated
The emission of GHGs i.e. CO_2 & CH_4 from the decomposition of organic waste is calculated using the equations 1 & 2.

RESULT

The estimated population of the city in 2018 is 3,474,271 and organic waste produced is 1.3 kg/capita/day which results in 4517 tonnes of waste per day. Figure shows the increase in emission of CO_2 from 562.2 kg/day to 745.3 kg/day and figure shows CH_4 emission increased from 44.3 kg/day to 58.7 kg/day, this increase in emission is attributed to increase in waste from 3407 tonnes/day to 4517 tonnes/day for 2008 and 2018 respectively. The total carbon dioxide and methane emission accounts to carbon footprint of 1978.1 kg/day in terms of equivalent carbon dioxide.

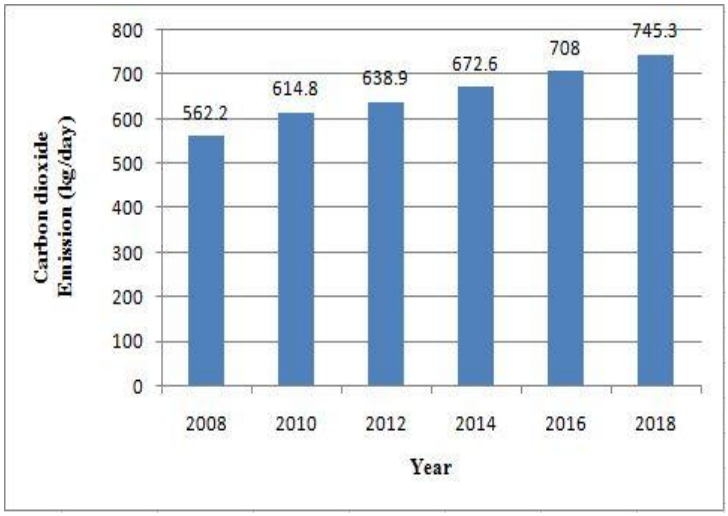

Figure 3: Carbon dioxide emission

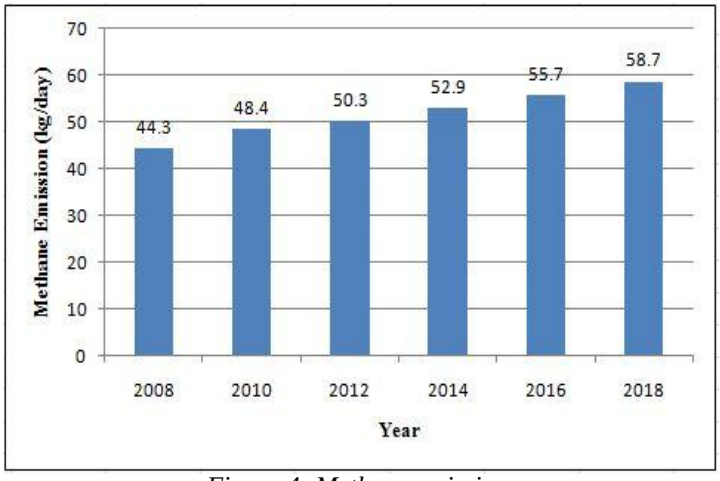

Figure 4: Methane emission

CONCLUSION

The GHGs emission from the degradation of organic waste contribute to the increase in concentration of these gases in atmosphere which is the reason for global warming and climate change. Due to the improper waste management practice in the city the emission are lead into the atmosphere. Methane is a main constituent of natural gas, technologies like bioreactor and microbial electrolysis cells can be used for waste management to capture this gas and use it as a fuel, this will help in reducing the use of fossil fuels which have adverse environmental impacts [5].

REFERENCES

[1] Wiedmann, T. and Minx, J. (2008). A Definition of 'Carbon Footprint'. In: C. C. Pertsova, Ecological Economics Research Trends: Chapter 1, pp. 1-11, Nova Science Publishers, Hauppauge NY, USA.
[2] Boucher, O., Friedlingstein, P., Collins, B. and Shine, K.P., 2009. The indirect global warming potential and global temperature change potential due to methane oxidation. Environmental Research Letters, 4(4), p.044007.
[3] Francis, R.C., Singh, L.P. and Prakash, E.V., 2013. Solid waste management and characteristics in Lucknow, Uttar Pradesh, India. International Journal of Scientific & Engineering Research (1645-1648), 4(11).
[4] Kulkarni, G., Bajpai, V., Sheng, S., and Ramachandra, T.V., "Carbon Footprint of Municipal Solid Waste in Greater Bangalore," LAKE 2012 Natl. Conf. Conserv. Manag. Wetl. Ecosyst., no. November, p. 8, 2012.
[5] Chynoweth, D.P., Owens, J.M. and Legrand, R., 2001. Renewable methane from anaerobic digestion of biomass. Renewable energy, 22(1-3), pp.1-8.