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Comparative Flux Estimation Study of Methane and Carbon Dioxide between Unmanaged and Managed Landfill Sites of Udaipur, Rajasthan

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Abstract

Landfill sites are grabbing the attention due to the noxious emission of green house gases (GHG's) into the atmosphere. This is anthropogenic emission source holds third position in the world. The present emission flux study of methane and carbon dioxide was done in two landfill sites situated outside the city of Udaipur, Rajasthan. The extensive field monitoring was done for a period of two years i.e. from Jan.2018 to Dec.2019 at Titardi and Balechha landfill sites by using protocol as mentioned in IPCC, 2006 guidelines for static flux chamber method. The chamber was connected with respective CO2 and CH4 analyzers for direct measurement that records in concentration (ppm) over time (sec.) on heterogeneous surface area of these two sites. The emissions flux rate was ranging not be ignored so, needs proper attention either to mitigate its detrimental effects or utilized as a source of energy for other sectors. No one had chosen these two sites (BLS & TLS) earlier for the measurement of GHG fluxes so, forms as the first report. This intensive field study will help in diminishing vulnerabilities in the estimation of CO2 and CH4 fluxes. The leachate analysis is needed to be done further for assessing the environmental threats as a good research scope in these sites.

Keywords: Anthropogenic source; Landfill emanations; Flux chamber; Leachate analysis

Introduction

The land filling is the best practice adopted years ago to manage the municipal solid waste (MSW). The day by day increment in MSW volume acquires more and more land which results in shortage of land becomes a major issue for its management. India is one of in the top 10 countries who are highest in producing MSW. In India the generation of MSW per capita on daily basis is ranging between 0.25 to 0.50 kg. Approximately India is generated 62 million tonnes of trash annually this rate of increase can be challenging for this nation to resolve garbage problem till 2030. The Indian Municipal corporations since, 2014 under the Swachh Bharat Mission has been primarily focusing and following one of the most substantial guideline i.e. segregation of MSW at source level before land filling. The unmaintained landfills and the open dumping sites attract birds, flies and insects thrives diseases to nearby residents. At the time of raining the waste heaps permeates high amount of tainted fluid called leachate. It differs broadly in organization relying on the time of landfill and the constituents it contains poses potential threat to water, soil.These sites also have capacity to develop and discharge enough amount of gases majorly that can have detrimental effect in the surrounding environment and in long time period enhances the global temperature. The organic fraction in MSW is higher in developing countries as compared to the developed nations and it is responsible for GHG emanation and leachate formation There are various factors causative for outflows such as composition, age, compaction and volume of trash besides this the external factors like moisture, pH and temperature are also contributed. That is why both the gases differ in their volume percentage during aerobic and anaerobic decomposition of organic garbage. Out of the total landfill gas (LFG) generation fluctuated between 40-60 % and other gases 1-2 % by volume reported by The Kyoto conventions powers to mitigate or reduce the discharge of those gases which are anthropogenic in origin and can alter the natural GHG impact. Along these lines the landfill trash composition need to be analysed and emission utilize for energy production. A new concept of MRV (measurement, reporting ad verification) introduced in Bali action plan to extenuate the GHG emanations. The striking rate of increase in mean concentration i.e. more than 400 ppm reported in Mauna Loa situated in Hawai. This concentration has been varying greatly or even higher in local and regional levels due to the influence of climatic conditions and source sink relation. This ascent embroiled owing to the current enormous alterations in land use and anthropogenic discharges. On the other hand, a comprehensive study will be needed to understand the impact of anthropogenic activities on discharge gases characteristics and this requires data that consists of the share of different sources to inclusive event of emission. Moreover, less consideration is generally observed at regional and local grounds to assess the discharges from the landfill MSW so, needs to be addressed. The state wise inventory based on theoretical estimations of GHG was prepared by "GHG platform India 2005-2015 State Estimates - 2019 Series" showed vide range of vulnerability in data. The actual field based examinations of landfill GHG emission inventory is absent in India. The in situ GHG emission measurements on landfill surface in this manner bears incredible pertinence it not just diminishing data inconsistencies, yet in addition to that it also reflects the shareholding of local and regional sources to discharges of GHG. The current investigation was done in two landfill sites of Udaipur primarily dedicated to estimate the fluxes for a period of two consecutive years (2018-2019) and the obtained results were statistically analysed and compared with other measured data of the previous research work. With the population of 1.2 million, the city witnesses unprecedented growth of MSW every year. The amount of MSW produced in Udaipur is around 200 tonnes per day (Municipal Corporation of Udaipur). Being a tourist place the city receives visitors throughout the year known as floating populace. Thus, the

generation of waste by travellers cannot be ignored and the huge portion is also added by the residents of this city. The MSW of the city consists predominantly the organic waste fraction which is in the form of biodegradable, compostable furthermore, recyclable materials. These are some the reasons for undertaking the investigation as it has environmental and scientific pertinence. It also forms as a base for the National GHG emission measurement inventory. This is the first coverage as no one has studied earlier on the estimation of GHG outflows from this place [1-3].F

Materials and Methods

The current examination was conducted monotonously for a period from Jan.2018 to Dec. 2019 to estimate fluxes from two landfill sites of Udaipur. Semi arid tropical climatic conditions are prevailing in this region. Summer, monsoon and winter seasons are distinct with average annual rainfall of 637mm. At the time of study, monthly mean maximum temperature was fluctuating from and minimum temperature existing between 8.2 to 25.7. In winters there are some instances when temperature drops down to below 0°C especially in night. The general wind blow direction is south west to north east throughout the year. The texture of soil in this region is sandy loam to clayey loam having the pH ranging from 6.7 to 7.8. The two monitoring sites selected for the study was Titardi landfill site (TLS) is 20-25 years older site about 7.3 km away from the city situated in southern part has occupied 190000 area. From the last 5-6 years the site is converted into a sanitary landfill area where the waste dump of approximately 18 mts in height and about 30mts width is developed with proper capping and lining system to avoid the leachate spillage and gaseous release. The composting and plastic processing unit is also set up within this landfill area for the treatment of 30 tonnes of the collected waste. The other was Balechha landfill site (BLS) in the northern region about 9 km away from the Udaipur city has covered the area of 540000. This site is being the functional from 2008, used for the dumping of 70-80 % of the total MSW collected. The composition of the MSW alters monthly and seasonally. Generally the city contains waste in the forms of food waste, excavated soil, cardboard, all types of plastic, packaging material, rubber tyres, metal, glass, textile pieces, construction and demolition waste [4,5].

The investigated protocol comprised of two levels of examination in which the measurements of fluxes in the field and the waste assortments analysis in the laboratory. The objective was to assess the degree of decomposition within the waste mass that was responsible for the GHG emanations in two landfill sites (point source discharges). In brief the work plan consisted of two landfill sites+two gases +thirteen waste characteristic parameters.

The emission estimation of both these gases was done from Jan. 2018 to Dec.2019 at the BLS and TLS. The frequent and intensive monitoring was done to achieve the reliability in the emission fluxes data. Often use technique appropriate for examining the gas exchange between landfill surface and the atmosphere reported. When the box is placed over the ground that sealed by its edges develops the gas pressure inside. The rate of increase in concentration of gas with time at certain level is constant represented by linear regression to estimate the flux [6].

The BLS and TLS were divided into four and three zones respectively. Each zone was segmented into 12×12 meters grid for the placement of the flux box in the centre. Through this technique more and more points were covered to get the better representative sample from each zone and no area was left for the sampling. Before the commencement of each sampling event the iron rim was fitted about 4-5 cm in the soil. The static flux box was a rectangular box having dimensions of 60cm ×14cm× 33cm made of plexi glasses supported by iron edges was inverted inside the rim and water was filled in the gap between the rim and the box to avoid air ingress. A battery operated rotator was also adhered to the inside wall of the box for air circulation. The top of the inverted box had two holes equipped with rubber septum one for placing the thermometer and other for collecting the gas samples. A long plastic pipe was running from the gas aperture of the box was bifurcated into two for connected it to the analyzers. The CH4 analyzer was detecting in the range of 0-1ppmv and 0-20000 ppmv measurements limit of the CO2 detector. In this way the instantaneous emissions were measured from smaller surface points at a time interval of 0, 5, 10, 15, 20, 25, and so on in ppm/sec (A handbook of portable flux meter, 2007).

As mentioned earlier the chamber temperature was measured at each sampling point in addition to that MSW pH and moisture was also noted in the observation sheet. The recorded mean values were used to assess their individual effect on the emission.During summer the temperature of MSW was in the range. At certain range of temperature varied types of microorganism functions differently in the course of MSW fermentation process. These bacteria activates in the range of 38-50ºC, 30-35ºC and 48-65ºC to initiate methanogenic, mesophilic. The temperature of monsoon and winter was favourable for the mesophils to work predominantly. Fluctuations in temperature throughout the year impact the microorganism activities that further affect the degradation of MSW. The previous studies of also emphasised that a sharp increase in MSW temperature and moisture was induced the gaseous release from the landfill surface into the air environment. Moreover, pH below neutral is a good indicator of degradation process that was responsible for the generation of CH4 found. The change in composition of the waste with seasons was brought variation in the operational variables that ultimately affects the gas production. The average values of all the parameters tabulated were correlated with the flux values to know the impact of each parameter on rate of emissions. The ambient temperature and humidity conditions were measured with the help of temperature sensor and hygrometer respectively [7].

Results and Discussion

The field monitoring results and its discussion

The two years fluxes were recorded through intensive field monitoring revealed that TLS have comparatively lower emission fluxes than BLS. The BLS is an open dumping site with unmanaged in its arrangements. However, TLS is sanitary landfill area where proper capping and lining systems are being used for managing the disposed MSW. The seasonal fluctuations were observed at both the sites. Especially during summer season the fluxes in august which was found to be much than as recorded in other two months as wells as from the data of BLS. The rate of degradation in fresh waste was much faster than a year old waste and the proportion of newly dumped waste was higher in BLS that was one of the probable reasons for getting the more flux values than TLS consistent with the findings of, Moreover, the microbial activity within the waste mass was accelerated by the increase in the temperature that can be responsible for the excellent emission of CH4 and CO2 from the landfill area in Italy had estimated the fluxes of CH4 between 0-3500 at as these

fluxes were extremely higher than the results got from two landfill sites of this study i.e. only ranged between 0.087 to 0.252 The TLS and BLS have estimated flux values of CH4 was lower than CO2 represented that both landfills under the acetogenic phase i.e. III phase of the MSW degeneration procedure reported by. It also implied that both the sites have significant waste deposition that took 1-3 years for maturation [8].

In winter the fall in the air temperature increases the landfill cover soil porosity that do not allow the gases formed during the microbial fermentation process occurred in the embedded waste layers to escape from the soil surface reported by In brief the seasonal changes in the external factors such as humidity, temperature and pH can be responsible to the temporal fluctuations in emission of CO2 and CH4 from the landfill surface. The role functional parameters like CH4 oxidation, acetogenesis, acidogenesis and methanogenesis can also be crucial for the variation in emissions of the same. These regulating factors were studied during the landfill gas emanations process [9].

The dense contours were representing the waste saturated zone with plenty of biodegradables responsible for fermentation activity that contributed to higher emissions fluxes 'hotspots region' as compared to the other zones of the landfill. Thus, hotspot regions were playing the substantial role in determining the total GHG emission from the entire landfill area. These Hotspot zones were unevenly scattered over the complete landfill area so, random point sampling would not considerably be a worth full option for accounting the total GHG fluxes from the entire area of landfill. The contours of low and negligible fluxes of both these gases were overlapped on the aged waste and soils enrich regions. Heterogenecity in the fluxes were found at both the sites over space and time as mentioned earlier. MSW laid over the different patches of the landfill have varied level of decomposition that releases characteristic gases into the atmosphere [10].

The current investigation also correlated the environmental factors; organic waste constituents with the mean emission fluxes refer to the correlation matrix as illustrated in that have showed the average, low and strong correlation among all of these. Specifically the air temperature, MSW temperature, moisture, organic carbon and total nitrogen content had showed the strong correlation at $p<0.01$ level of significance with fluxes. The similar trend of correlation where $R=0.245$ between the mean flux and the temperature at $p<0.01$ level was reported by However, the weaker correlation was also existed among fluxes, air humidity and volatile solids of MSW. There was non-correlation reflected between the two gaseous fluxes and calorific value of MSW. These results were contrasted with the outcome of the study of where, he found positive and negative correlation of flux with MSW moisture and temperature respectively. Thus, the impact of all these variables can be varying from one landfill site to another. During the low precipitations the fluxes were rises and both showed the strong correlation with MSW humidity reported.

The statistical interpretation of the data as presented in the exhibited the significant variability in the data emission fluxes of the constituents of MSW were assessed in the laboratory and their results indicated that organic carbon content was higher in BLS waste as compared to TLS which accelerates the decomposition activity might be reason of higher emission fluxes of both the gases [11].

Conclusion

In the current investigation the flux chamber technique was applied with point grid method for the accounting of fluxes from BLS and TLS. It was revealed through this study that environmental and waste variables were the indicators of GHG emissions. The hot spots of GHG emission fluxes were located during the event of sampling and recording. These discrete blocks in the landfill area was significantly impact the total emissions. The temporal and spatial variation brought fluctuations in the fluxes of the determining factors were environmental and MSW compositional both. The BLS had sufficient quantitative emission fluxes of than TLS. BLS and TLS contributed about equivalent of the GHG emissions was also confirmed that maximum emission from the landfill surface. The BLS has no gas control or utilization system on the other hand TLS was covered with liners and soil to minimize the emissions. The aerobic decomposition process of the organic waste within the freshly disposed waste mass was generated the higher amount in both the sites. The retention time of biogenically produced in atmosphere is long so, stimulates the surface mean temperature that can bring adverse ecological and human effects. The fluxes were reportedly higher from the other landfill sites in India due to extensive two years field monitoring. This examination might be helpful for those who will form the GHG inventory of small cities specially the waste sector. In addition to that these GHG's can be utilized for energy generation which also gives economic benefits. The author has investigated trash sector GHG's discharge quantities by considering the two landfill sites. The other aspects like energy generation potential of GHG's bio-mining, bioremediation and the leachate pollution are not covered yet so, need to be acknowledged.

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