H. B. SAHU
and
KUSHAL TIBREWAL

Greenhouse gas inventory for mines: an urge to develop clean technology

As the global temperature is on the rise due to global warming, the issue of climate change is indeed a hot topic among the climate scientists and policy-makers worldwide. Claiming anthropogenic emissions as the primary cause of the prevailing climate change, every human activity is now under heavy scrutiny. Among others, mining is one of the fundamental activities which caters to the supply of raw materials to other basic industries and fulfils most of the energy needs of the human race and is believed to be a major contributor to the anthropogenic emissions. The present paper discusses a few case studies conducted in some Indian mines to estimate their respective carbon emissions. The accounting of carbon emissions due to mining activities is called as 'greenhouse gas inventory'. A brief look over the GHG inventory of some mines provides a succinct idea about contribution of mining industry to global emissions. The results highlight that emissions from mining industry are significant and cannot be overlooked. Thus it is required to develop clean technology to be implemented in mines to lower its emissions.

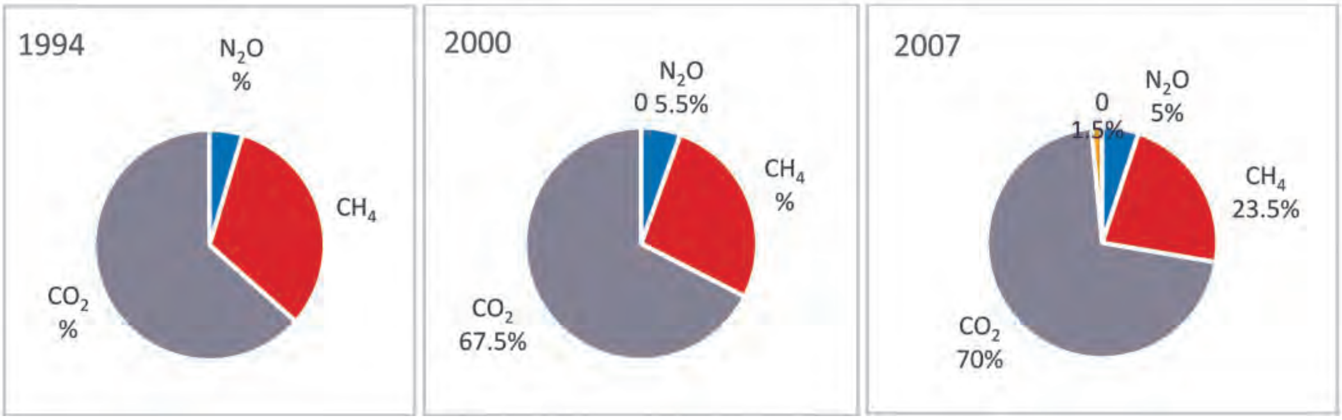
Introduction

The threat of climate change is soaring at an alarming rate and so is the consensus among the people. The amount of CO_2 is increasing incessantly in the atmosphere, rising the global surface temperature by 1.2ºC approximately [1]. This increases in the CO_2 levels is believed to be a consequence of man-made activities such as industrialisation, urbanisation, transportation etc. Thus, it is regarded as anthropogenic emissions. This is a matter of serious concern as it accompanies catastrophic consequences. Scientists claim that the global temperature will continue to rise which may result in more drought and heat-waves, melting of glaciers, rise of sea levels and altering of precipitation patterns [2]. Climate scientists, meteorologists, policy-makers and governments all-round the globe have unequivocally accepted the existence of climate change and are breaking their backs to mitigate this impending hazard. Thousands of scientists are working rigorously under the umbrella of several international organisations and programmes such as the Intergovernmental Panel on Climate Change (IPCC), NASA, United Nations Framework Convention on Climate Change (UNFCCC), United Nations Environment Programme (UNEP), World Meteorological Organization (WMO) etc. to assess the climate change and provide a scientific view on the current status of knowledge in climate change and its consequences. It is recommended that one of the key steps towards controlling climate change is to identify the sources of CO_2 and other major greenhouse gases (GHGs), measure their emissions levels. Following this, the activities with high emission levels can be substituted with cleaner technologies. This urges the need to develop cleaner technologies which will release less amount of GHGs and compliment the process of controlling climate change.

Dr. H. B. Sahu, Associate Professor, Department of Mining Engineering, NIT Rourkela 769 008, and Mr. Kushal Tibrewal, Phd Student, IDP Climate Studies, IIT Mumbai 400076

Greenhouse Gas (GHG) Inventory

Since, scientists globally attribute the prevailing climate change to the anthropogenic emissions of CO_2 and other major GHGs, it is thereby required to keep a regular track of their emission levels [3]. This process of accounting the emission levels of CO_2 along with other major GHGs from different sources for a concerned activity is referred to as carbon footprint or greenhouse gas inventory. Based on the type of activity in hand, there are broadly three types of carbon footprint, namely organisational footprint, product footprint and personal footprint. Organisational footprint involves the calculations of emissions from all the key sources of an organisation, company or an industry. Product footprint covers the emissions liberated in the activities performed during the making of a product. Lastly, personal footprint records the emission levels of an individual during a specified period of time [4]. The IPCC and Greenhouse Gas Protocol provide a universal standard to record and maintain the inventory of a particular activity. It involves setting up a boundary within which the sources will be considered, recording the amount of sources exploited for that activity-called as the activity data, and multiplying it with the emission factor i.e. the amount of particular gas liberated during the consumption of per unit quantity of the source. Each gas, to be measured, has its own emission factor for a particular activity. Finally the total emissions for each gas from each



N_2O = Nitrous Oxide, CH_4 = Methane, CO_2 = Carbon Dioxide, FCs = different forms of fluoro-cCarbons

Fig. 1 Trend in GHG emissions in India for the years 1994, 2000 and 2007

activity is multiplied by its corresponding global warming potential and summed up to obtain the total emissions in the form of carbon dioxide equivalent (CO_2-e) [5][6].

Reporting of GHG inventory

As the need for calculating GHG inventory grew, it paved way for an international platform, the United Nations Framework Convention on Climate Change (UNFCCC), to report the GHG inventory prepared by different countries. Under the programme of UNFCCC, different countries signed the Kyoto Protocol, a treaty which aims at reduceing the greenhouse gas emissions. Till date, 195 countries have signed the treaty and participated to control their respective carbon emissions and are referred to as the "Parties to the convention". According to the protocol, different countries have a varying level of responsibility towards limiting their emissions. The developed countries have a legal binding to report and take immediate steps to check their emissions within the specific limit, whereas the developing nations are required to report their total emissions but are not compelled to check these. Moreover, it is proposed that the developed nations must provide the developing countries with appropriate technological assistance to reduce their emissions [7].

India being a developing nation, does not have a legal binding to control its emissions, but since it is a participant in the protocol, it is a beneficiary to the technological support from the developed countries. Presently, India is stated as the third largest emitter with 5.2% of total global emissions. It follows the United States of America contributing 14.1% which follows China, the highest contributor of greenhouse emissions with nearly 21.1% of the total global emissions [8]. India signed the UNFCCC in the year 1992 and reports it emissions to it via the National Communication to the UNFCCC (NATCOM). India has prepared two reports of National Communications, which contained the detailed estimation of emissions from major sectors, for the year 1994 (Initial National Communication) and 2000 (Second National Communication). Apart from submitting for the UNFCCC, India developed a GHG inventory of its own for the year 2007 which was brought out by the Indian Network of Climate Change Assessment (INCCA). According to the reports the trend in the GHG emissions for the years 1994, 2000 and 2007 are shown in Fig.1 [9][10][11].

India's mining sector

Mining involves the extraction of minerals that supplements the need of raw materials for many basic industries and thus, is an integral cog in the process of development. India is known to have rich reserves of minerals which makes the mining sector, a fundamental prerequisite for the nation's development. The judicious and planned exploitation of these reserves can make the country self-sufficient in meeting its energy demands, raw material requirements for industrial development and foreign trade in the form of mineral exports. Thus, mining is a very crucial industry for a developing nation like India.

One of the major uses of mining is the extraction of coal and other conventional fuels to meet the energy requirements of the country. It is found that coal and lignite are the primary sources of energy production in our country accounting for almost 74% of the total production for the year 2013-14. Electricity generation is the biggest consumer of coal with thermal power plants accounting for a whopping 70.25% of the total installed capacity in the country, followed by steel industries [12]. Thus, it is quite evident that our country relies largely on mining industry for its energy requirements. Mining involves use of heavy machines, blasting equipment, mineral processing plants, and coal-handling plants etc. which are a huge source of GHGs. Therefore, mining is a significant contributor to the present global warming menace due to release of CO_2 and other GHGs. And the scale at which it is happening in our country, it cannot be neglected.

Mining GHG inventory

Reporting of GHG Inventory exclusively for mining industries is still integrating at a slow pace. However, there are a few mining companies which have been conscious of the present need of the hour and taken initiatives to estimate their GHG inventory. Moreover, major scientific research institutes, independent organisations and research fellows have also stepped forward for estimating carbon emissions on behalf of many mines.

Sasan Coal Mine (Sasan Power Ltd.) [13]

Sasan UMPP is India's one of the largest opencast coal mining projects located in the Singrauli Coalfield. The total production from the mine is 470.43 MT with the peak production of 20 MTPA. To compile the GHG inventory, methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions are considered. The sources of emissions were limited to emissions due to consumption of diesel from mining machines, methane trapped in coal bed, and due to electricity used for construction and equipment running. For the life of mine, the estimated average GHG emissions in the form of CO_2-e per tonne of coal produced is found to be 29692 g/T. The distribution of total emission under each source is shown in Table 1.

Durgamanwadi Bauxite Mines (Hindalco Industries) [14]

Karthik Kumar and Shreya Uttarwar conducted a brief attempt to calculate the carbon dioxide emissions from various activities of a bauxite mine. The mine chosen was Duragamanwadi bauxite mines of Hindalco Industries. The default international DEFRA emission factors were used to estimate the CO_2 levels for electricity consumption, LPG consumed in canteens, fuel consumed by employee transportation and fuel consumed in mining machineries. Moreover, monthly activity data of the sources were considered to extrapolate it to estimate the yearly CO_2 emissions. According to this study, the total CO_2 emitted by the mines is found to be 6210.44 Tonnes/yr. The distribution of total emissions for each source is presented in Table 2.

Table 1 Distribution of total CO_2-e emissions under each source for Sasan Coal Mines

	Fuel	Avg. CO_2-e emissions (g/tonne)
1	Diesel/oil usage	2210
2	CH_4 emissions	27460
3	Electrical energy	21.6
	Total	29691.6

Table 2 Distribution of total CO_2-e emissions under each source for Durgamanwadi Bauxite Mines

	Fuel	Avg. CO_2 emissions (tonnes/yr)
1	Electricity	64.44
2	LPG from canteen	2.5
3	Employee transport	13.5
4	Mining machines	6130
	Total	6210.44

Ashoka Project and Piparwar Project (Central Coalfield Ltd.) [15]

cBalance Solutions Pvt. Ltd. with the guidance of IIM Ahmedabad and CIMFR, Dhanbad prepared the GHG inventory for two prominent mining projects of Central Coalfield Ltd.(CCL), a subsidiary of Coal India Ltd. (CIL) – Ashoka project (OCP) and Piparwar project (OCP). Ashoka project has produced an average of 7.9 MTPA of coal while Piparwar project produced about 10.7 MTPA of coal during 2010-13. The calculated inventory is in accordance with the standards proposed in the GHG Protocol's Corporate Accounting and Reporting Standard. As per the GHG protocol, the organisation boundary was set such that the inventory includes only those activities which are under 100% operational control of the company. And under operational boundary, those activities were categorised as Scope 1 (direct emissions) and Scope 2 and 3 (indirect emissions). The emission factors for respective activity data were gathered collectively from 2006 IPCC guidelines for National GHG Inventories, Central Electricity Authority, CIMFR Database and Forest Survey of India 2008-10: Carbon Stock in India's Forest. The estimated inventory report is summarised for Ashoka and Piparwar project in Tables 3 and 4 respectively.

Samleswari Opencast Project, MCL

The below estimations are the result of the self-study conducted for Samleswari OCP in Mahanadi Coalfields Ltd. (MCL), a subsidiary of Coal India Ltd. The boundary of the study were limited to mining lease boundary and the sources of emissions taken into account are the electricity consumption and fuel consumption by the mining machines. The results were obtained for a period of one month. The monthly production of the mine for that particular month was 927844 tonnes of coal. The findings from the study are summarised in Table 5.

Table 3 Summary of Inventory report for Ashoka Project

Year	Total emissions (tonne CO_2-e)	Coal production (tonne)	kg CO_2-e per tonne of coal produced
2010-11	2,25,287	80,30,254	28.05
2011-12	2,12,921	77,18,410	27.59
2012-13	2,11,219	80,01,373	26.40

Table 4 Summary of Inventory report for Piparwar Project

Year	Total emissions (tonne CO_2-e)	Coal production (tonne)	kg CO_2-e per tonne of coal produced
2010-11	3,12,716	1,00,00,000	31.27
2011-12	3,26,621	1,06,55,531	30.65
2012-13	3,41,797	1,15,00,000	29.72

TABLE 5 SUMMARY OF CO_2-E EMISSIONS FINDINGS FOR SAMLESWARI OCP

Scope	Source	Equipment	Consumption	CO_2 – e Emissions(kg)
2	Electricity (kWh)		1186531	925494.2
1	High speed	Dumpers	172385	439630.1
	diesel	Water sprinklers	15577	39725.71
	(litres)	Dozers	53795	137192.3
		Graders	7243	18471.68
		Drills	16890	43074.23
		Shovels	125100	319040
		Auxiliary	2213	5643.77
		Total		1928272

Discussion

The above studies show a wide range of CO_2-e emissions for mines as the emissions ranges from just 6210 tonnes of CO_2-e per year to a whopping 3,60,000 tonnes of CO_2-e per year. Such significant variation can be attributed to the different methods and standards used by the industries in calculating their emissions. Moreover, many sources of emissions may have been neglected due to inadequate data or lack of feasibility. This non-uniformity in the results urge for a more tedious and careful calculation of the emissions. There is a need for development of a common standard and methodology with pre-defined sources and with appropriate emission factor relevant to Indian conditions which must be followed by every mines for a more equitable and fair comparison of emission results.

From the report prepared by the Indian Network of Climate Change Assessment (INCAA), the GHG emissions in terms of CO_2-e for the year 2007 from the major sectors were estimated to be approximately 719.31 million tonnes for electricity eeneration, 123.55 million tonnes and 10.21 million tonnes for road and air transport respectively, 129.92 million tonnes for cement industry, 117.315 million tonnes for iron and steel production and 334.41 million tonnes for the agriculture sector [11]. Currently, the total number of reporting mines is found to be 3699 for the year 2013-14 [16]. Thus, taking the average GHG emissions per mine from the above collected studies and multiplying it with the total number of reported

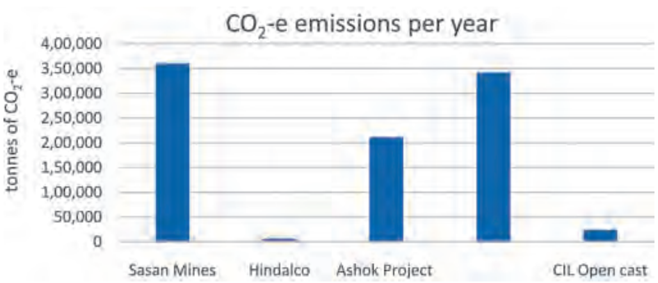


Fig 2 Comparison of CO_2-e emissions per year from various case studies

mines, it is found that the contribution of mining industry towards India's overall emissions is quite significant and needs equal attention as the other key industries.

Conclusion

The presented studies of GHG inventory of a few Indian mines give a brief idea about the contribution of mining industry to the present global threat. It is quite evident that like other major industries such as thermal plants, metal industries and agriculture sector which have already been identified as "key sources" of emissions, contribution from mining industries to the carbon emissions is quite significant. The results, although incurring many uncertainties, urge the industrialists and policy-makers to conduct more thorough studies of carbon emissions for Indian mines and develop cleaner technologies for mining to reduce these emissions.

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