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ESTIMATION OF GREENHOUSE GAS EMISSION FROM COAL MINING IN BANGLADESH THROUGH LIFE CYCLE ASSESSMENT (LCA)

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Abstract*- Bangladesh - one of the fastest growing economies of the world - has enhanced the living standard of 160-million people creating a heightening demand for electricity. Coal is identified as the main fuel for electricity generation. However, attaining Sustainable Development Goals (SDGs) requires Bangladesh to curb greenhouse gas (GHG) emission while coal consumption aggravates it. Consequently, serious evaluation of using coal is needed. Accordingly, this study aimed to prepare a life cycle inventory of coal mining in Bangladesh with quantification of GHG emissions thereof. The estimated Global Warming Potential (GWP) due to GHG emission from 1-kg energetic coal mined in Bangladesh is 0.05 kg CO_2-eq. Electricity used in mining contributed the most (82.9%) to GWP. Also, underground activities need keen attention to improve GHG emission. Finally, the study indicated the need for a detailed energy audit to enhance energy efficiency. Taking energy from solar park on subsided land at the mining site may help reduce GWP of coal in Bangladesh.*

1. INTRODUCTION

Bangladesh is among the most densely populated countries in the world and a fast-growing economy with an estimated GDP growth rate of 7.9% [1]. The country is trying to sustain and sped-up its economic growth by emphasizing on industrialization. Consequently, a large amount of electricity as energy is required to thrive the stable economic growth. To address the increasing demand for energy, the Government of Bangladesh has adopted a new power generation strategy that aims to establish 13 new coal-based mega power plants in collaboration with foreign countries by 2023 [2]. Consequently, a whooping amount of coal will be required in near future, which the Government plans to arrange from both domestic sources and import [3]. In Bangladesh, domestic coal plays a significant role the energy sector as well as mining activities in sustainability of coal supply chain. There are seven coal reserve in Bangladesh viz. Jamalgonj, Barapukuria, Phulbari, Khalaspir, Dighipara, Nawabgonj and Dangapara. Among all these coal deposits, Barapukuria is the only operational coal mine in the country of 34 Million metric ton recoverable coal reserve along with 1 MT of annual average coal extraction capacity [4-6].

Coal has been the most popular source of energy because of its economy though environmentally unsound. As the sustainability of energy sector will play a pivotal role for the country to attain accelerated economic growth while achieving sustainable development goals (SDGs), the country needs to critically evaluate the options to make the domestic extraction of coal environmentally sound. Around the world, sustainability of coal is assessed through different approaches and Life Cycle Assessment (LCA) is the most common among them [7-11]. Accordingly, this study aimed to prepare a preliminary Life Cycle Inventory (LCI) of coal mining and assess Greenhouse Gas (GHG) emission from the entire process. Accordingly, the study will provide a report that will help the country to attain the Sustainable Development Goals (SDGs).

The study aims to help conducting complete life cycle assessment of coal for the whole economy of the country. Moreover, finding of the study will also take Bangladesh a step ahead to attain sustainable development goals (SDGs) along with an evaluation of existing mining practice by ensuring more environmentally sound coal supply for energy production.

2. METHODOLOGY

2.1 Process description

Barapukuria - the only operational coal mine of Bangladesh - is located in the north-western part of the country at Parbatipur upazila under Dinajpur district [12]. After all necessary technical and feasibility studies, Government of Bangladesh decided to establish the mine and a coal-based power station for uphold national energy sector in 2003 [13]. Since 2013 Longwall Top Coal Caving (LTCC) mining method was adopted to increase the production capacity. Mining activities include two major phases - underground mining and surface mining both with different specific activities. For instance, caving, shearing, roof support, transportation, crushing, cleaning, storage etc. An illustration of mining activities of Barapukuria is presented in the **figure 1.**

2.2 Goal and Scope

This study aims to conduct a preliminary life cycle inventory followed by estimation of greenhouse gas (GHG) emission due to coal mining activities in Bangladesh. Functional unit of the study was 1 kg read-to-use coal mined from Barapukuria coal mine in Bangladesh. The temporal scope of the study was the Fiscal Year 2017-18. All data were collected based on annual coal production to prepare the LCI and this was converted for functional unit.

System boundary of the study started from mining activities and confined to preparation of energetic coal ready to use. Mining activities require a wide range of inputs including electricity, fuel, timber, steel, water etc. Land is also occupied for mining activities. Underground mining includes extraction of coal form mine to carry the bulk on to the surface. Major share of energy and equipment are required in this phase. On the other hand, surface mining requires less inputs than underground operation. Storage of extracted coal, its maintenance and office management are the major activities in surface mining phase. After these two phases, energetic coal is ready to use by the adjoining power plant beside brick fields and other industries all over the country. System boundary of the study is illustrated in the **figure 2.**

Fig.1: Mining activities of Barapukuria coal mine

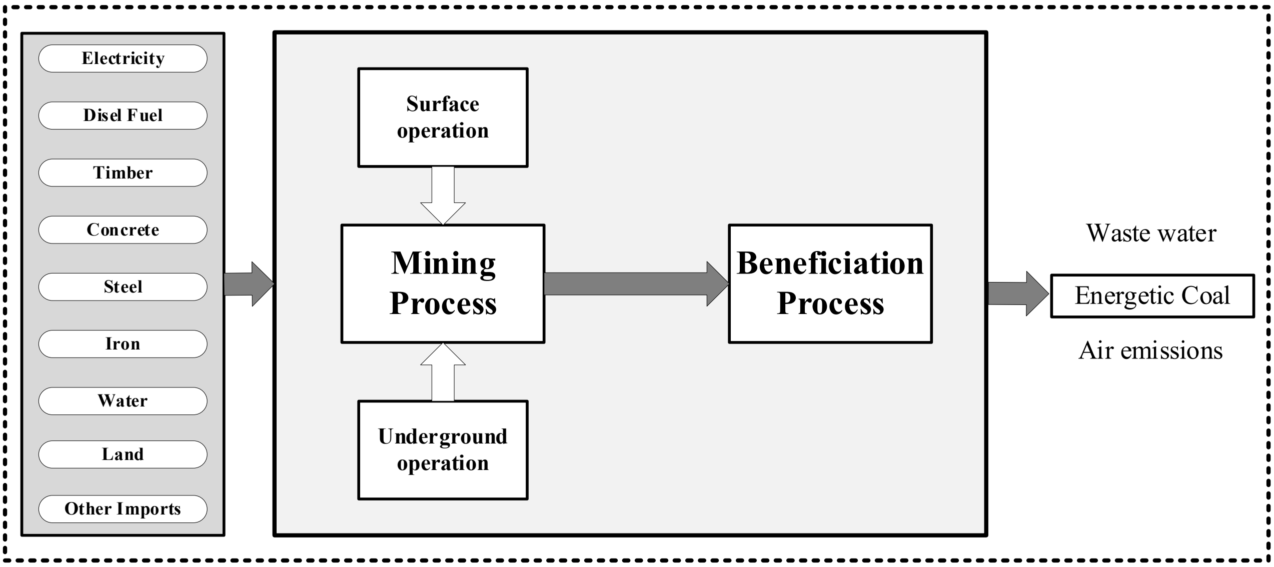

Fig. 2: System boundary of preparing energetic coal considered in the study

2.3 Life Cycle Inventory (LCI)

ISO 14044 provides a clear requirements and guideline for conducting LCA [14]. Present study adopted ISO guideline to perform the entire study [15]. LCI includes different steps. First of all, data was collected for inventory preparation, which consisted of energy and material inputs and outputs along with waste and emissions to air, water and soil. Primary data was collected from the field survey with semi structured questionnaire and secondary data was gathered from different scientific journal articles, national reports and newspaper articles. After this step, data validation was performed. Data was arranged according to functional unit as per unit process. Finally, inventory calculation and inventory preparation steps were done. **Figure 3** shows the procedure of LCI.

2.4 Life Cycle Impact Assessment (LCIA)

Mining related data was collected precisely and then all the data was arranged according to the functional unit by using Microsoft Excel 2016. CML baseline impact assessment method was used to evaluate the global warming potential [16]. All the assessment was performed by Simapro life cycle assessment software based on connection of ecoinvent database [17, 18]. Ecoinvent database is widely used database for LCA, which contains large number of country specific and global datasets compared to other existing databases.

Process specific data collection is very difficult in Bangladesh due to lack of transparency, poor record keeping and bad practices. On the other hand, ecoinvent database does not contain all country specific processes. Therefore, in this study the datasets were chosen from global and other countries' following comparable practices as in Barapukuria.

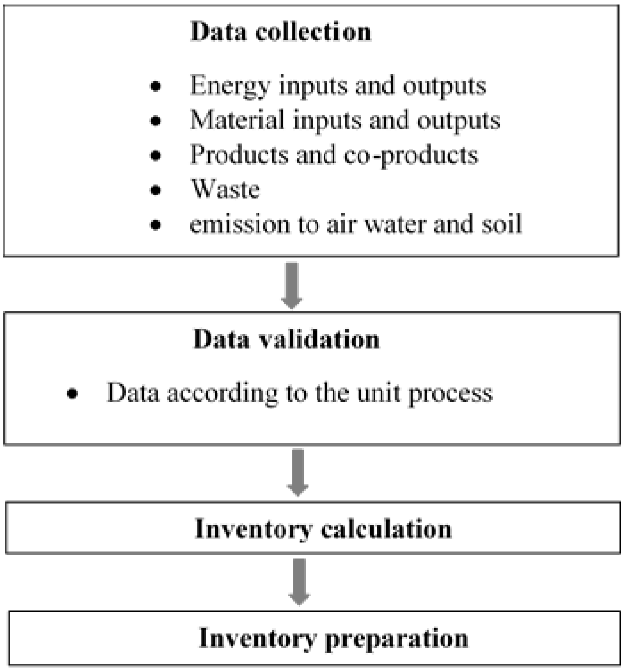

Fig.3: Life cycle inventory procedure

3. RESULTS AND DISCUSSION

3.1 Life Cycle Inventory (LCI)

LCI included all inputs from technosphere and nature as well as all outputs to air, water and soil in relation to mining of 1kg ready-to-use coal. LCI data was collected for the fiscal year 2017-18. Table 1 shows inventory of energetic coal extraction.

Table 1: Life cycle inventory of 1kg energetic coal extraction in Bangladesh

Inputs		
Item	**Unit**	**Amount**
Coal slurry	m^3	8.70E-07
Diesel oil used	Liter	3.57E-04
Petrol oil used	Liter	5.43E-06
Electricity use	kWh	4.76E-02
Occupation dump site	m^2	6.04E-05
Occupation, mineral extraction site	m^2	4.16E-04
Reinforce steel used	kg	8.70E-04
Wood log/timber	m^3	6.78E-07
Tap Water used	kg	1.03E+00
Lubricating oil	kg	1.45E-05
Polyethylene	kg	3.83E-07
Cotton	kg	1.72E-06
PVC	kg	1.72E-06
Rail track (total length)	km	4
Outputs		
Item	**Unit**	**Amount**
Waste water	m^3	1.02E-02

3.2 Life Cycle Impacts

The Global Warming Potential (GWP) related to extraction of 1 kg of ready-to-use coal from Barapukuria coal mine was 0.05 kg CO_2-eq. Underground operations were responsible for bulk of the generated impact compared to surface operations (**Figure 4**). In comparison, GWP of 1 kg of coal from a coal mine in Brazil was a comparable 0.0856 kg CO_2-eq [9]. In contrast, studies from China and UK reported higher GWPs - respectively 0.348 [8] and 0.149 [7] kg CO_2-eq per kg of energetic coal. The reason of variation lies in the involvement of a high GWP transportation phase for China and UK in contrast to Bangladesh where coal mine uses only low-GWP rail transport to carry out coal from mine to surface area.

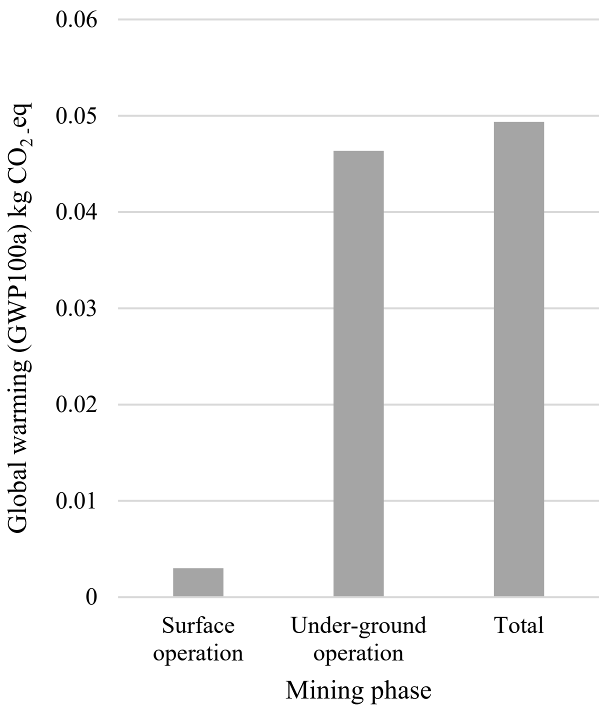

Fig. 4: Global Warming Potential of coal mining activities in Bangladesh

Figure 5 shows percentage contributions of major processes on GWP of mining 1 kg energetic coal by a sanky diagram. Clearly, underground operations had the highest (93.9%) contribution to GWP. Electricity was dominant (82.9%) over fuel and other material consumptions since a huge amount of electricity was consumed by underground mining equipment as well as for the maintenance of coal storage on the surface. Impacts of mine infrastructure (10.3%) and the use of steel (7.36%) were respectively second and third major contributors to GWP.

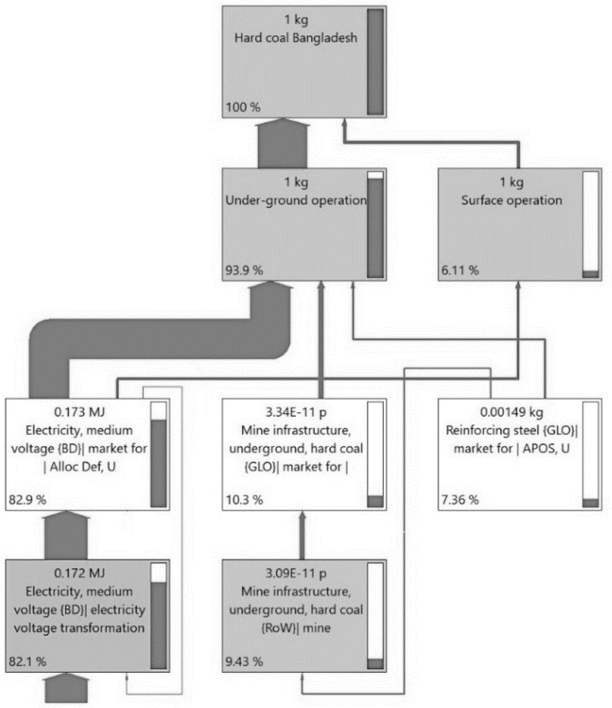

Fig. 5: GWP hotspots for mining 1 kg energetic coal in Bangladesh.

Hotspot analysis (**Figure 6**) identifies areas for action to enhance sustainability by providing crucial sustainability indications. The results can be used by governments, organizations and other stakeholders related to coal. At Barapukuria coal mine in Bangladesh, underground operation's sustainability was influenced mainly by electricity consumption (82.54%) followed by underground mine infrastructure development process (10.93%), steel use (4.61%), water consumption (1.64%) and other existing processes (0.28%). On the other hand, surface operations' sustainability bearing was comparatively lower than underground operations where major sustainability hotspot was electricity consumption (88.9%) followed by rail transportation for bringing mined coals to surface (6.9%) and diesel consumption for vehicle (4.1%). Clearly, electricity generated more burden on GWP in both the phases since mining operations were mainly run by electricity from national grid that had high GWP. Enhancement of efficiencies of current machineries through detailed energy audit may help to reduce the GWP while sourcing renewable energy from a captive solar plant on unused subsided land at Barapukuria coal mine area may substantially reduce the GWP to make the coal produced from the mine environmentally more sustainable.

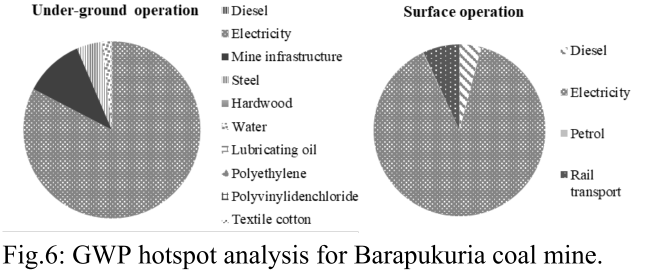

Fig.6: GWP hotspot analysis for Barapukuria coal mine.

4. CONCLUSION

Coal is considered as the most abundant and widely used fossil fuel resource as it plays a crucial role to provide cheap energy on which the world can rely on. Accordingly, Bangladesh is now focusing to develop coal-fired power plants to support heightening demand for electricity. However, coal emits a large amount of GHG than other energy sources that makes it more pollutant than others. This study aimed to prepare a preliminary life cycle inventory and identify the GHG emission as GWP of 1 kg of energetic coal extraction in Bangladesh through LCA. The GWP was 0.05 kg CO_2-eq – which was lower than other reported studies from Brazil, China and UK. Underground operations contributed to bulk of the GWP. Hotspot analysis identified electricity use as the main contributor to GWP in both underground and surface operations. Based on this, the study proposed detailed energy audit to enhance energy efficiency mainly in underground operations while suggesting the installation of a captive solar park to generate and consume renewable energy on subsided land to attain higher sustainability in coal production in Bangladesh.

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