

# Ash Content and Its Relevance with the Coal Grade and Environment in Bangladesh

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**Abstract**— This study presents the ash concentration and grading of coal of major coal fields in Bangladesh. Thirteen coal samples have been collected from Barapukuria coal field to measure the ash content whereas the values of ash concentration of other coal fields have been taken from a reference source. Ash concentration of Barapukuria coal field have been measured by standard method in laboratory. The results show that the average ash content of Barapukuria coal field is 9.61 % while Jamalgonj, Khalashpir, Phulbari and Dighipara contain 22.4-24.2, 21.8, 15.0 and 11.29% respectively. The grade of Jamalgonj, Barapukuria, Khalashpir, Phulbari and Dighipara coal fields are poor, good, poor, fair and good respectively based on ash concentration. This study also deals with the common constituents of coal ash. Several kinds of impacts (e. g. health, environmental and boiler) of coal ash are also discussed in the study. From the values of ash concentration, it can be seen that the coal of Barapukuria, Phulbari and Dighipara might cause less environmental and health destruction while Jamalgonj and Khalashpir coalmine's coal will cause much hazard.

**Keywords**— Coal, Ash Content, Coal Grading, Different Coal Fields in Bangladesh, Constituents of Coal Ash, Environmental Impact.

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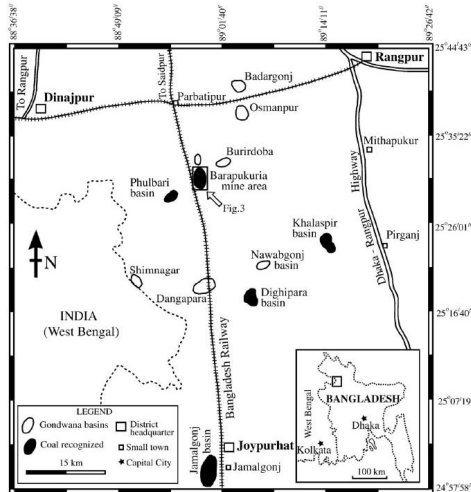
## 1. Introduction

Coal ash is the waste that is left after coal is combusted (burned). It includes fly ash (fine powdery particles that are carried up the smoke stack and captured by pollution control devices) as well as coarser materials that fall to the bottom of the furnace [1]. It is actually the non-combustible inorganic remains that are left after burning of coal. The inorganic matters include clay minerals and silt particles of quartz, carbonate, iron oxide and sulphur compounds [2]. Coal ash contains a variety of concentrated heavy metals, including many known carcinogenic and neurotoxin chemicals like arsenic, cadmium, hexavalent chromium, lead, mercury and selenium which are extremely destructive for health and environment

[3]. Living next to a coal ash disposal site can increase risk of cancer or other diseases [4]. The problems associated with ash in combustion and gasification systems include deposition on refractory and heat-transfer surfaces, corrosion and erosion of system parts, fine particulate that is difficult to collect, and maintaining slag flow in slugging systems [5]. Ash is unwanted in coal and it degrades the value of coal [2].

Five major coal deposits have been discovered in Bangladesh in the Northwest region (see figure 01). These include Jamalgonj, Barapukuria, Khalashpir, Phulbari and Dighipara [6]. In-situ coal resources of these coal fields are 2513, 377, 828, 426 and 600 Mt respectively (see table 01) [7].

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**Fig. 01: Location of major coal fields in Bangladesh [8]**

Intention of this research is to assess the ash concentration of Barapukuria coal field which is currently under production in Bangladesh. Then, taking the ash concentration value of Jamalganj, Khalaspir, Phulbari and Dighipara from a reference source. Next task is grading of five major coal fields in Bangladesh based on ash concentration. Finally, major constituents of coal ash with weight percentage and possible impacts of coal ash with weight percentage and possible impacts of coal ash on health, environment and combustion boiler in coal powered industry are discussed.

**Table 01: Summary of the major coal fields in Bangladesh [Case of the Dighipara coalfield [9]. Discovery dates [10]. Other resources [8]**

Coal fields	Discovery date	Areal extent of basin (km <sup>2</sup> )	Number of coal seams	Depth range of coal seams (m below surface)	In-situ coal resource (Mt)	Aggregate thickness of coal-seams (m)
Jamalgonj	1962	11.7	7	650-1158	2513	64
Barapukuria	1985	5.2	6	118-518	377	51
Phulbari	1997	51.9	2	150-250	426	38.4
Khalaspir	1987	12.3	8	257-483	828	42.3
Dighipara	1995	Unproven	1	328-422	600	42

## 2. Methodology

### 2.1 Materials and Instruments

Thirteen coal samples of Barapukuria coal field are the primary materials used in this study. Various types of instruments such as Crusher, Pulveriser, Tray, Flask, Cupel, Crucible, Oven, Balance (sensitive to 0.0001 g), Tongs, Spatula and Muffle Furnace were used to determine ash content of these coal samples.

## 2.2 Testing Procedure

Weigh 1g of air drying coal samples with granularity of 0.2mm or less with the use of dry and clean cupel and spread it out eventually through the cupel. The cupel with contents is placed into a Muffle Furnace of room temperature. The temperature of the Muffle Furnace is raised to about 500°C in 60 minutes. During the next 60 minutes the temperature is raised to about 820°C and kept at least 60 minutes at this temperature. After incineration, take the cupel from the furnace, place it on the heat resistance asbestos board, cool it for about 5 minutes in the air, and then move it to the drier to cool to ambient temperature for about 20 minutes and then weigh it.

The formula to determine ash content is,  $Aad = \frac{(m_3 - m_1)}{(m_2 - m_1)} \times 100\%$

Where, Aad=Ash Content of air dried coal sample,  $m_1$ =weight in gm of empty cupel,  $m_2$ =weight in gm of cupel and sample before burning,  $m_3$ = weight in gm of cupel and sample after burning.

## 3. Result and Discussion

### 3.1 Measured Ash content of the coal samples of Barapukuria coal field

The Barapukuria coalfield is located in the Rnagpur saddle of the stable platform of Bangladesh and is surrounded by Himalayan foredeep to the north, the shilling shield to the east, and the Indian peninsular shield to the west [11]. There are six coal layers (seams) referred to, from top to bottom, as seam I, II, III, IV, V and VI encountered with in Gondwana rock unit in Barapukuria basin. The coal seams occur at depths ranging from 118 m to 506 m below the surface. Three of the coal seams, i.e. II, IV, and VI are major. The remaining three coal seams, i.e. I, III, and V are discontinuous and irregular [2]. It is one of the largest Bangladeshi coal fields, currently

under the production state which contains more than 377 million tons of coal.

Ash is a secondary determinant of coal price while heat and sulfur content are considered as the primary determinants in international table [12]. In fact, ash concentration of coal is inversely proportional to coal price. That is why; ash is an important property of coal. Ash concentration of collected coal samples of Barapukuria coal field are given in table 02.

**Table 02: Ash Concentration of Barapukuria Coal Field**

Sample No.	Ash content (%)	Sample No.	Ash content (%)
01	9.30	08	10.05
02	7.33	09	9.88
03	6.30	10	8.81
04	8.87	11	10.20
05	10.19	12	11.39
06	8.96	13	9.77
07	13.92		
Average ash content= 9.61 %			

### 3.2 Ash Content based Coal grading of different Coal Fields in Bangladesh

Ash is unwanted and degrades the calorific value of coal. A greater mass of high ash coal must be used to provide a given amount of heat due to dilating effect of the non carbonaceous components. Also, greater amount of waste need to be removed after utilization [2]. Thus the lower amount of ash in coal is extremely important for coal's purity and high price. That is why coal

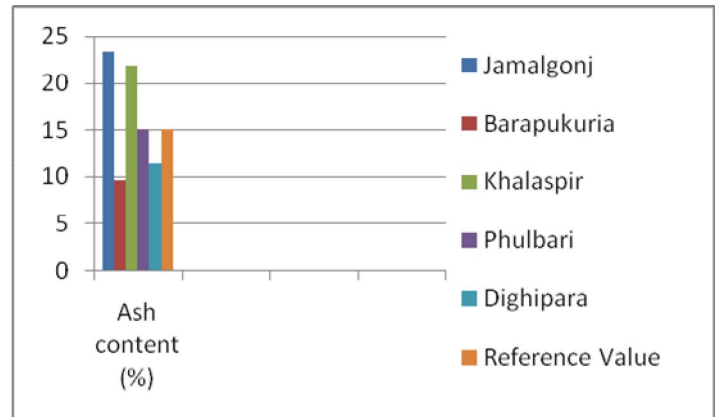
gradation is done based on ash content. In case of coal grading, Ash < 8% for Superior coal, Ash ≥ 8 but < 12 for Good coal, Ash ≥ 12 but < 16 for Fair coal and Ash > 16% for poor coal [13]. The average ash content of coal of Jamalgonj, Barapukuria, Khalaspir, Phulbari and Dighipara are 19.96, 8.87, 13.12, 14.4 and 10.14% respectively and the grade of these coal fields are poor, good, fair, fair and good respectively (see table 03).

**Table 03: Ash content of coal of major coal fields in Bangladesh and their grading (case of ash content of Barapukuri [lab test], other coal fields [2])**

Coal Field	Jamalgonj	Barapukuria	Khalaspir	Phulbari	Dighipara
Ash Content (%)	22.40-24.20	9.61	21.8	15	11.29
Coal Grade	Poor	Good	Poor	Fair	Good

### 3.3 Comparison of Ash Contents of Bangladeshi Coal Fields with Reference Value

Higher amount of ash content reduces the calorific value of coal, causes health and environmental damages and lowers the boiler efficiency. Thus ash content is important parameter to determine the coal price as coal's purity and efficiency greatly depend on ash content. Ash should be < 15 % for steel grade-1 coal [14]. Ash content of Barapukuria, Phulbari and Dighipara coal field lies within this range while the ash content of Khalaspir and Jamalgonj coal field is higher than acceptable range (see figure 02 and table 03).



**Fig 02: Comparison of ash contents of several coal fields of Bangladesh with reference value**

### 3.4 Common Constituents of Coal Ash

The chemical composition of coal ash (bottom ash, fly ash, and slag) varies widely, in concentrations of both major and minor constituents [15]. Chemical constituents of coal ash may include nitrogen, sulfur, unburned carbon, heavy metals, radioactive elements, and polycyclic aromatic hydrocarbons (PAHs) [16, 17]. Mineral matter or inorganic material (see table 02) is always present in coal and forms a residue of ash when coal is burned. Coal ash generally weighs less than the mineral matter from which it is derived, because certain constituents are lost in the ashing or burning process. Many silicate minerals in coal contain water of hydration that is driven off; pyrite (FeS<sub>2</sub>) is converted to ferric oxide (Fe<sub>2</sub>O<sub>3</sub>); and calcite (CaCO<sub>3</sub>) is decomposed to calcium oxide (CaO), with loss of carbon dioxide (CO<sub>2</sub>). Part of the sulfur of pyrite is retained in the ash as calcium sulfate (CaSO<sub>4</sub>) [18]. Coal Ash is comprised chiefly of compounds of silicon, aluminum, iron and calcium with smaller amount of compounds of magnesium, titanium, sodium and potassium. They occur in ash as a mixture of silicates, oxides and sulfates with small quantities of phosphates and other compounds. The composition of ash from different coals varies widely, depending on the quantities of clay, shale, pyrite, calcite and other minerals present in the coal.

**Table 04: Inorganic constituents of coal [15, 18, 19, 20]**

Inorganic Constituents	Forms in Coal	Range
Silicon	Silicates and sand	25-60 (Wt %)
Aluminum	Alumina in combination with silica	10-30 (Wt %)
Iron	Pyrite and marcasite (sulfide), Ferrous oxide, Ferrous carbonate, Ferrous sulfate, Ferric oxide, Ferric sulfate, Organic iron and Iron silicates	5-40 (Wt %)
Calcium	Lime, Carbonate, Sulfate and Silicates	0.5-25 (Wt %)
Magnesium	Carbonates, silicates	0.2-8 (Wt %)
Sodium and Potassium	Silicates, Carbonates, Chlorides	0.2-8 (Wt %)
Manganese	Carbonates and Silicates	50-10,000 (ppm)
Sulfur (inorganic)	Pyrite and marcasite, Ferrous	0.2-20 (Wt %)

### 3.5 Possible Impacts of High Ash Coal on Environment

Toxic coal ash threatens health and environment [21]. People can be exposed to coal ash from disposal sites and environmental contamination. Living near coal-fired power plants, coal ash ponds, landfill sites, or coal ash amended soil puts people at risk of exposure to coal ash [22, 23]. Exposure may occur through inhaling air or drinking water polluted by coal ash [22]. Coal ash ponds and landfill sites may leach into drinking water sources. Exposure may also occur due to uses of coal ash in public areas, workplaces, and homes. Coal ash is commonly used as filler material in a wide range of materials, including soil, bricks and cement, driveways, building sites, and recreational areas like sports fields and golf courses [23, 24]. People may also be exposed through consumption of food contaminated by coal ash, such as eating fish that have been exposed to contaminants in coal ash or eating foods grown in soil that has been amended with coal ash. Coal ash contains a variety of concentrated heavy metals, including many known carcinogenic and neurotoxin chemicals. If eaten, drunk or inhaled, these toxicants can cause several kinds of diseases to human being (see fig. 03).

Ash, as a solid waste material, is generated due to coal combustion. These ashes are usually collected in the Electrostatic Precipitators (ESPs) and dispose off in the ash ponds or in the open lands and some of these enter into atmosphere by passing through the stacks along with the flue gases. Toxic constituents of coal ash create poison into air, land and human drinking water and pollute them while blowing, spilling and leaching (dissolving and percolating) from storage units (see fig. 03) [25].

Pulverized-coal combustion gives rise to mineral species, vapour and particles of various sizes and compositions. Due this type of combustion in coal fired boilers, ash is deposited on heat exchange surfaces of boiler. Ash formation is affected by

boiler design, and by operating conditions such as the amount of excess air, and the distribution of coal through different burners [26]. Formation of

ash create some problems to reduce the boiler's efficiency (see fig. 03).

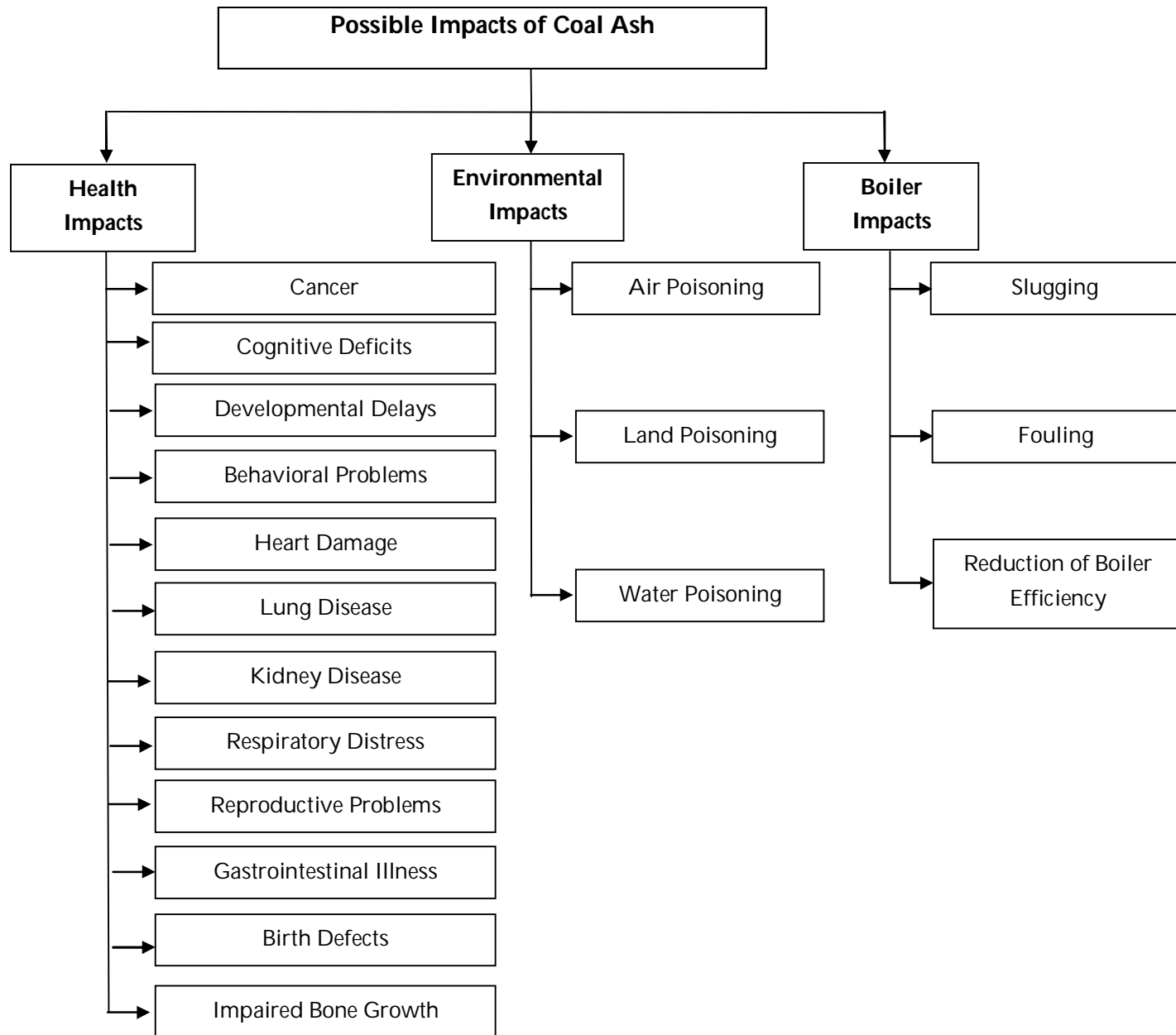


Fig 03: Possible Impacts of Coal Ash on Boiler Efficiency, Environment and Health

#### 4. Conclusion

Bangladesh has very small amount of natural gas remaining and almost there is no crude oil. So in future years, Bangladesh may rely on coal resources for energy.

Barapukuria coal field, which is under production, is one of the largest Gondwana fields in Bangladesh, with an area of 5.61 Km<sup>2</sup>, an estimated in-situ coal of about 377 million tons. Jamalgonj, Khalashpir, Phulbari and Dighipara coal fields contain 2513, 828, 426 and 600 million tons of coal respectively.

This study presents the ash concentration and coal grading of major coal fields of Bangladesh. It also present the possible impacts of high ash coal on health, environment and boiler in coal powered industry.

High ash coal damages environment, health and coal powered industry. It creates several kinds dangerous diseases in human body. High ash coal pollute air, water and land. Moreover, combustion boiler efficiency is reduced by ash deposition on heat exchange surfaces of boiler in coal powered industry. Thus high ash reduces the purity and price of coal.

In Bangladesh, Barapukuria, Phulbari and Dighipara coalmines contain small amount of ash. Even coal of these coal fields are steel grade- 1 coal. So, coal of these fields would cause less hazards on health, environment and industry. That is why, policy makers should take initiatives to extract coal from this field with full capacity to fulfill the energy demand of the country.

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