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An Ultimate and Artifice Paradigm to Achieve Feasible and Environment Friendly Coal, Reducing Sulphur During Conventional Chemical Methods

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Abstract: In Pakistan, our coal contribution is only 0.3% besides having huge domestic resources i.e. 185.175 billion tones of which 99.7% is found in Sindh including Lakhra, Sonda, Thar and Jharrak etc. These are mostly lignite and needed to produce electricity urgently. In view of the enhanced coal utilization, a comprehensive assessment and evaluation of the coal quality including amount of trace elements in the ashes and combustive emissions going into the atmosphere is of crucial importance. Sulphur is the active problem in coal, generally present in the form of pyretic, sulfate, organic and elemental state. This cumbersome pollutant is the major reason for environmental upset in the surroundings and hence a pretreatment is essential to remove it totally or to reduce to an acceptable limit otherwise. Working with this task, found considerable reduction in total sulphur content having major part of pyretic sulphur whereas about 2/3 part of the organic portion of sulphur retained in the coal matrix. Following ASTM Float and Sink Method (D 4371-91) along with conventional acid and base treatments with coal achieved the above goal and concluded that the above method is found fit for Lakhra coal for its feasible utilization.

Key words: Lignite coal · Pollutants in coal and forms of Sulphur

INTRODUCTION

In the world energy scenario, by 2030, the global coal demand could rise upto 70% and the total energy demand to 55% making dominant the share of fossil fuels [1]. It wonders ourselves that Pakistan's coal reserves are now top up with sixth position in the world however, Pakistan is still an energy deficient country spending more than US $ 2 billion per year on import of fuel oil for energy needs. Pakistan has not yielded any concrete result due to multifarious reasons including technical, financial, geopolitical and political law& orders. Its natural gas reserves are depleting at a very fast rate in result of unlimited usage of CNG in luxury automobiles with not only in passenger vehicles. The nation requires adequate supply of energy for rapid industrialization as well as their household uses. It is high imperative that long term energy crises should be addressed diligently and indigenous sources of energy should frequently be exploited to curtail heavy foreign exchange being spent on energy bills. The Government of Pakistan in its long term energy plan has now recognized the need for the utilization of coal on merit as an alternate to natural gas/ furnace oil and has emphasized on its utilization in cement, brick kilns, sugar industry as well as in thermal power plants. Coal is thus expected to play an important role as a prime energy source in Pakistan in near future after the successful attempts on underground coal gasification [2].

Coal, which is widely available in Pakistan (Table 01), holds sufficient potential for meeting a considerable portion of our energy requirement [3]; [4]. Adverse factors like high sulfur, high ash and high moisture with low rank has to be addressed carefully through well planned research and development programs [5]. The need for utilization of coal in thermal power plants is a prominent factor in the energy sector of Pakistan. This might especially be achieved through the induction of private sector in power generation, as is being done in USA, China and other countries. The pollution problems associated with the combustion of coal in power plants have been recognized all over the world i.e, Kuto and carbon emission strategies Protocol etc. Intensive efforts have to be made for monitoring and combating these aggressive pollutants to minimize their adverse effects on human beings as well as on environment. In an in-house

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study, attempts were made to reduce sulphur and achieved good results aiming at the major pollutant [6]; [7].

MATERIAL AND METHODS

The samples had been collected from lakhra coal field and after sampling through ASTM methods, their routine analyses for proximate, total sulfur and forms of sulfur respectively performed. These samples were then treated configuring ASTM D4371-91 Float and Sink practice along with strong oxidizing and reducing agents subsequently through a systematic scheme [8] on ambient and optimum conditions. They were then washed with plenty of water and dried in an air drying oven before further analysis.

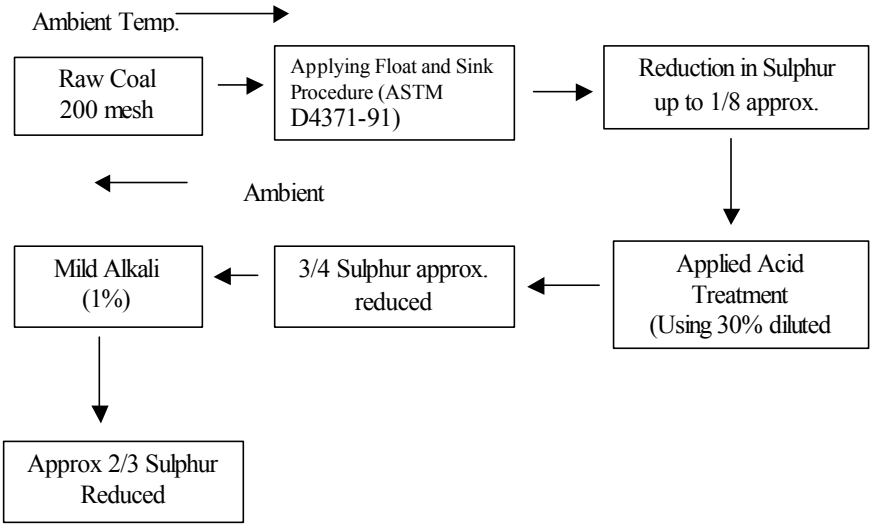


Fig. 01: Schematic Diagram of Environment Friendly Coal:

RESULT AND DISCUSSION

Sulfur is generally recognized as one of the major pollutants in coal at world coal resources and it varies from 0.19 to 10% where as in economically recoverable reserves it is from 0.83-5.32% [9, 10]. The adopted technology to control sulfur emissions is that of pre-treatment of coal before combustion [11-16]. However, under physical cleaning of coal for the removal of mineral matter by washing and through gravity separation now being widely practiced in the world coal industry [5], these also reduced 30-90% the pyretic sulfur present in coal along with the mineral matter [17] in addition to organic portion of coal which has sulphur as much as 50% remained yet in the matrix. It is necessary to treat coal chemically [18] to reduce both organic and pyretic sulphur to acceptable limits.

Organic and pyretic sulphur account together for the majority of sulphur in coal where as sulfatic sulfur occurs mainly as iron sulfate and gypsum. The latter obviously resulting from the iron pyrite oxidation and is present generally below 0.1%. Whereas elemental sulphur is also present in small concentration in coal i.e. 0.2% [19].

In 1960s, the usage of caustic at temperature 150-400°C to expel organic sulphur from coal was suggested [20] and during the course of study, potassium sulfide and potassium thiosulphate had been determined in the reaction products proposing the reaction

$$8FeS+30KOH \xrightarrow{\text{Temp: 150-400°C}} 4Fe_2O_3+14K_2S+K_2S_2O_3+15H_20$$

Oxidants starting from strong acids i.e. HNO_3, $HclO_4$ and H_2O_2 have much oxidation potential to interact with pyrites [9]. Several reactions involved in the reduction of pyrites have been reported [21] but the consumption of expensive reducing agents prevents their commercial applications for these reduction methods.

In our research study, we have adopted a conventional strategy following ASTM Float and Sink approach D4371-91, [14, 22, 23] configuring mild acid and base treatments subsequently. In result, sulfur reduced upto 2/3 of the total content found in the parent coal samples received from Lakhra.

Table 01: Typical Analysis of Pakistan Coals

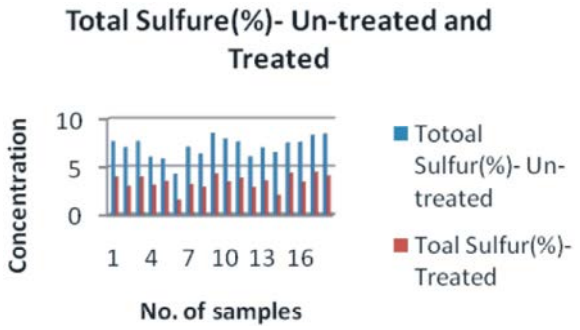
S.no	Name of Coal Field	Inherent Moisture (%)	Volatile Matter (%)	Ash. Content (%)	Fixed Carbon (%)	Total Sulfur (%)	Calorific Value (K. cal/kg)
01	Lakhra	13.5-39.4	26.3-42.5	7.4-25.0	20.7-39.2	1.8-9.85	2570-4200
02	Mach	7.1-12.0	34.5-39.5	9.6-20.3	32.4-41.5	3.2-7.4	5100-5730
03	Sor-Range Deghari	5.1-21.2	31.0-43.1	2.7-14.3	36.0-43.0	0.4-5.6	4830-6060
04	Pir Ismail Ziarat	5.2-10.0	27.0-41.5	13.3-34.2	23.8-37.2	-	5353-5939
05	Khost-Sharigh Harnai	1.7-11.4	29.7-45.7	9.3-38.0	25.5-45.2	1.4-9.4	4420-7000
06	Duki	4.8-9.2	36.5-53.0	2.7-22.3	14.3-38.9	2.7-7.7	4610-6380
07	Meting Jhimpir	26.6-36.6	25.2-34.2	8.2-16.8	24.1-32.2	2.9-5.1	3740-4260
08	Sonda	9.0-39.5	20.0-44.2	5.0-39.2	15.0-58.8	0.4-5.2	3600-5700
09	Salt Range	3.2-10.8	21.5-38.8	12.3-44.2	25.7-44.8	2.6-10.7	3760-6170
10	Makerwal	2.8-6.0	31.5-48.1	6.4-30.8	34.9-44.9	2.8-6.3	5200-6780
11	Khurd-Sho(NWFP)	3.0-5.8	30.2-45.2	7.0-9.0	31.1-40.2	3.0-5.2	5200-6100
12	Thar	35-50	35.4-48.3	4.9-26.7	29.8-33.3	0.66-3.4	4330-5855
13	FATA	1.80	16.39	39.67	43.4	5.46	4798

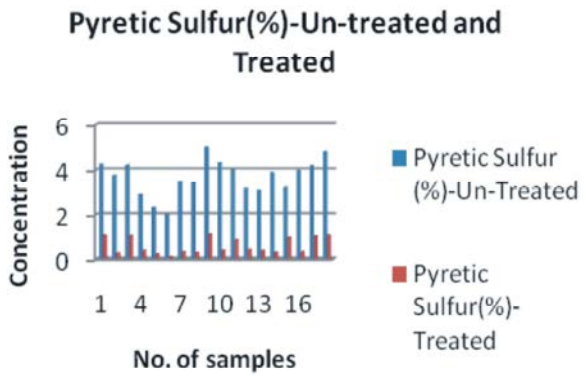
Table 02: Analysis of Lakhra Coal- forms of sulfur

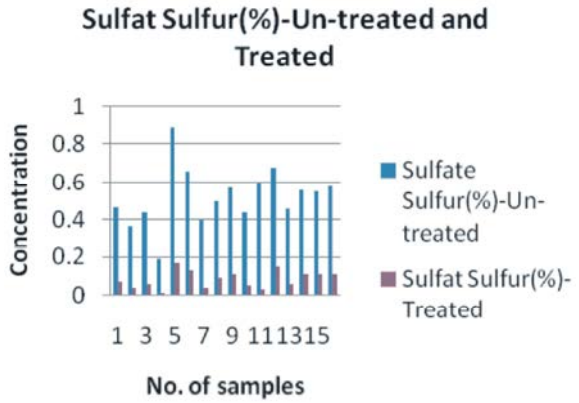
	Gun-treated Coal				Treated Coal			
S.no	Total Sulfur (%)	Pyritic Sulfur (%)	Sulfate Sulfur (%)	Organic Sulfur (%)	Total Sulfur (%)	Pyritic Sulfur (%)	Sulfate Sulfur (%)	Organic Sulfur (%)
01	7.59	4.24	0.47	2.94	3.97	1.09	0.07	2.81
02	6.98	3.75	0.37	2.86	3.00	0.27	0.04	2.69
03	7.61	4.20	0.44	2.97	3.97	1.08	0.06	2.83
04	5.99	2.89	0.19	2.91	3.11	0.39	0.01	2.71
05	5.81	2.31	-	-	3.49	0.23	N.D*	3.26
06	4.21	1.99	0.89	1.33	1.54	0.11	0.17	1.26
07	7.03	3.47	0.66	2.90	3.16	0.33	0.13	2.70
08	6.34	3.42	0.40	2.72	2.91	0.29	0.04	2.58
09	8.46	5.00	-	-	4.27	1.13	0.03	3.11
10	7.89	4.31	0.50	3.08	3.46	0.40	0.09	2.97
11	7.57	4.01	0.57	2.99	3.84	0.89	0.11	2.84
12	6.03	3.17	0.44	2.42	2.87	0.43	0.05	2.39
13	6.02	2.89	0.31	2.82	-	-	-	-
14	6.94	3.07	0.60	3.27	3.56	0.39	0.03	3.14
15	6.48	3.87	0.68	1.93	2.03	0.31	0.15	1.57
16	7.45	3.22	0.46	3.77	4.37	1.00	0.06	3.31
17	7.36	5.51	0.42	1.43	-	-	-	-
20	7.54	3.97	0.56	3.01	3.4	0.33	0.11	2.96
21	8.26	4.18	0.55	3.53	4.47	1.06	0.11	3.30
22	8.37	4.80	0.58	2.99	4.05	1.09	0.11	2.85
23	8.46	4.41	1.56	2.49	-	-	-	-
24	8.85	4.48	0.61	3.76	-	-	-	-
25	9.85	-	-	-	-	-	-	-

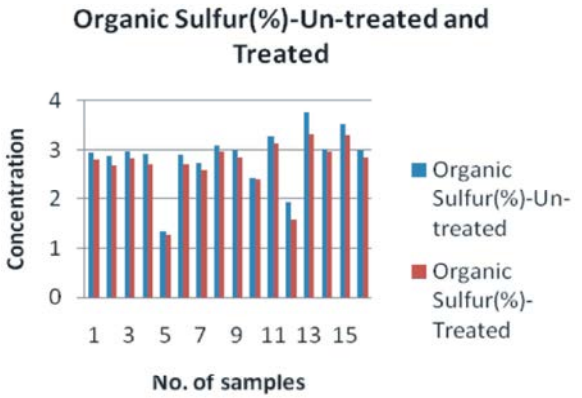
N.D*= not detectable

Graphical Presentation: (Figure 02-05)









CONCLUSION

The results of the treated coal (Figure 02-05) indicate that our adopted conventional method of washing for the lakhra coal is successful and may be commercialized in near future as the sulphur pollutant making environment suffocated and full of pungent small due to which house wives do not use coal for their domestic purposes.

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