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NEUTRALIZATION OF ACIDIC MINE WATER USING FLYASH AND OVERBURDEN

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ABSTRACT
Acid mine water bodies are one of the severe environmental problems in many mines including coal mines all over the world. This problem is also found in a few coal and metal mines of India. In coal mines, the main cause of acidity is the occurrence of pyrite and other sulfide metals in the form of a vein, granular and crystallized form in coal and shale.
In this paper, a case study of the utilization of Flyashand overburden for neutralization of acidic water of coal mine has been discussed. Theoretical and acid neutralization potentials of Flyashand O/B were determined. The acid neutralization potential of Flyashand O/B for acid water treatment has been tested in the laboratory by using Flyashand waste rock materials and acidic water of field. The results are encouraging and Flyashmay prove as a good acid neutralizer with coal overburden material.
Keywords: Flyash, Overburden, Acidic water, Neutralization, Environmental problem.

INTRODUCTION

In many countries, several rivers, streams and reservoirs are adversely affected by contaminated water draining from mines both, in active and abandoned stages. The "Zero Discharge Concept" is only true during the non-rainy season and in geologically good water retaining terrain. However, mines are always the constant source of contamination. As a result of variation in geology and mineralogy of coal and associated rocks from mine to mine, wide variation in quality of water occurs. The pH of water ranges from very acidic to very alkaline range.[1] Among objectionable parameters of water quality are low pH value and high level of sulfate, iron and total dissolved solids.[2] These parameters deplete oxygen content in water, increase the toxicity by rendering heavy metals soluble and create corrosion problems besides decreasing the aesthetic of the area. The highly acidic water not only damage to aquatic life but also corrodes pumps and pipes during its handling from mine to disposal sites. Such problems are common with metal sulfides mine. However, it is not uncommon in coal mines also in many mines of the world. India is no exception. Acid water from coal mines is a serious issue in Indian mining industry also, adversely affecting the water quality and in turn the environment. The pollution of surface water by acid mine drainage and mine effluents have serious environmental implication in and around coal mining complex [1]. Acid mine water bodies are one of the severe environmental problems in many mines including coal mines all over the world. This problem is also found in a few coal and metal mines of India. In coal mines, the main cause of acidity is the occurrence of pyrite and other sulfide metals in the form of a vein, granular and crystallized form in coal and shale.[3]

In this paper, a case study of the utilization of Flyash and overburden for neutralization of acidic water of coal mine has been discussed. Theoretical and acid neutralization potentials of Flyash and O/B were determined. The acid neutralization potential of Flyash and O/B for acid water treatment has been tested in the laboratory by using Flyash and waste rock materials and acidic water of field. The results are encouraging; O/B and Flyash may prove as a good acid neutralizer of acidic water. Flyash generation and utilization in different countries show that in Table-1.[4]

Table-1: Generation and utilization of Flyash in different countries

S. No.	Country	Annual ash production, MT	Ash utilization %
1	Australia	10	85
2	Canada	6	75
3	China	100	45
4	Denmark	2	100
5	France	3	85
6	Germany	40	85
7	India	112	38
8	Italy	2	100
9	Netherlands	2	100
10	UK	15	50
11	USA	75	65

Table 2: Overburden Removal in Indian Mines (2014-2015)

S. No.	Name of company	No. of surface mine	Annual production of overburden (Million m^3)
1	BCCL	15	103.901
2	CCL	35	97.378
3	ECL	18	94.047
4	MCL	14	89.221
5	NCL	08	210.614
6	NEC	02	10.185
7	SECL	19	158.268
8	WCL	33	122.914
Grand Total		144	886.5

Study Area

Singrauli Coalfield is spread across the districts of Singrauli and Sonebhadra in the Indian states of Madhya Pradesh and Uttar Pradesh, mostly in the basin of the Son River. The Singrauli Coalfield is located between latitudes $24^0$12’ N and $23^0$47’ N. It is spread over nearly 2,200 km^2 but only a small part of the coalfield, around 220 km^2, has been identified as promising by the Geological Survey of India. The north-eastern part of the coalfield sits on a plateau with an altitude of 500 m above mean sea level, well above the lower plains of 280 m altitudes. Northern Coalfields Limited was carved out of Central Coalfields Limited in 1986, to take care of operations in the Singrauli Coalfield. The proved reserves in the Moher basin are about 3 billion tonnes out of which 2.3 billion tonnes have already been planned for mining, in an area of about 84 km^2.

Topography

The Singrauli coal field stands as high plateau over the surrounding planes covered by Talchir sediment. The Barakar sediment projects over the Talchir outcrops as scrap faces. Towards North, the Gondwana sediment abuts against Precambrian rocks, which form a series of East-West trending prominent ridge. The Singrauli plateau rises to a height of over 500m. Above mean sea level, (M.S.L.) from the Southern plane, which has a general level of about 275m.from above M.S.L.

The plateau, which is referred to as Mohar plateau, has step-like scrap faces towards the south. The steps appear to represent different stages of peneplanation. The different platforms are of a remnant type, resulting from erosion of gently inclined sedimentary strata of varying resistance. Physiographically, the eastern part of the coalfield in U.P., is characterized by a cluster of hills and plateau to the north and undulating plains to the south. The western part of the coalfield also comprises a platform with a slope towards east and south, where there are abrupt drops of 50 to 60m in altitude. Towards southwest, several high peaks such as Popari (508m) and Burma (564m) are prominent topographic features.

Climate, Flora and Fauna

The coalfield experiences a tropical monsoon type climate. Though, the winters are rather cold (5-10^{0}C), the summer temperature often shoots up to 46^{0}c in the daytime. The area enjoys a rather heavy monsoon and the annual rainfall varies between 125cm and 150cm.the wild animals are depleting and many have migrated to more remote areas due to mining and allied activities. The ground especially the elevated areas, is mostly covered with open forests of Kendu, Mahua, Bija, A.

Location and Description of Water Sampling Sites

For such a study the sample locations are very carefully chosen so that they are representative samples. Thus, samples were collected from various strategic locations. The water sampling locations were identified with the objective to assess the physicochemical characteristics of mine water across the mine. To get firsthand knowledge of water quality in the study area, water samples were collected in the one-liter plastic gallons. The location of sampling sites was selected in such a way that water analysis data reflect the water quality with mining operations at one place and also provides actual concentrations of objectionable parameters at that particular location. Each location has an identification number after the sample collects from mine.

EXPERIMENTAL

Collection of Flyash

The Flyash used in the present study was collected (Hindalco power plant, Renusager) in a dry state from electrostatic precipitators. The mineral matter associated with the coal, such as clay, quartz, and feldspar disintegrate or slag to varying degree. The finer particles that escape with flue gases are collected as Flyash using electrostatic precipitators in hoppers and stored. The hoppers have small outlets. Gunny bags made of strong poly-coated cotton with 50kg capacity each were used to collect the dry fly ash. The chute of hoppers was slowly opened and the bags were filled. The mouth of each bag was sealed immediately after collection and the same was again inserted in another polypack to prevent atmospheric influences. The bags were transported with almost care from the plant to the laboratory and kept in a secure and controlled environment. Samples of Flyash were taken out as per requirement of the test.

Physical Characteristics of Flyash Analysis

Flyash is spherical particles makes up 10 to 85% part of the total coal ash residue, usually ranging in diameter from 0.5 to 100 microns[1]. It is a heterogeneous material primarily consisting of amorphous aluminosilicate spheres with minor amounts of iron-rich spheres, some crystalline phases, and a small amount of unburned carbon. Chemical composition and SEM analysis of Flyash as given Table-3 and Fig.-1, respectively.

Table-3: Chemical Composition of Flyash

Component	Bituminous	Subbituminous	Lignite
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

Collection of Overburden

Sample collections were carried out from all parts of the dump area. Gunny bags were used to collect the loose soils sample leaving the gravels, boulders etc. aside. The process followed for Flyash collection was also repeated to collect overburden material. The sample was properly packed and brought carefully to the laboratory at IIT, BHU for physical and chemical analysis. The material was explored in the laboratory crushing, grinding and sieved to discard gravels, pebbles (Fig.-2).

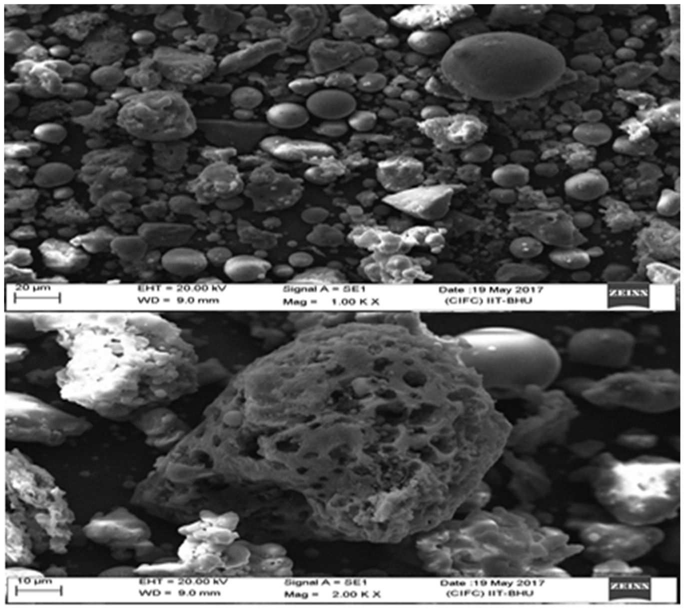

Fig.-1: SEM analysis of fly ash

Characteristics of Overburden

The overburden rocks in the study area are friable, loose, and non-cohesive in natural and the size varies from boulder to clay. In the present study area mine has been divided into two sections the east and the west with a central exit ramp. Both the external and internal overburden dumping methods are adopted during the mining processes. During external overburden dumping, contour strip benches are prepared to stabilize overburden dumps.[5] These benches improve dump stability against slope failure and reduce surface erosion by reducing slope length.[6] The initial overburden dump of 97 million cubic meters has been removed as external overburden dumps on the east and the west side of excavations. These fill the southern boundary valley and extend over the plain to the south. Samples for testing were selected and collected that those represent the average materials found in the mine. Physico-mechanical properties of OB dump materials and Texture Analysis of Overburden (Singrauli) are shown in Tables-4 and 5 respectively.

Table-4: Physico-mechanical properties of OB dump materials

S. No.	Properties	Value
1	Optimum moisture content (%)	10
2	Wet density (g/cc)	2.28
3	Dry density (g/cc)	2.08
4	Specific gravity	2.56
5	Direct shear test (degree)	35
6	Cohesion (MPa)	1.07
7	Triaxial test (degree)	35
8	Liquid limit	-
9	Plastic limit	-
10	Permeability (K) (cm/sec)	1.71x10-5

Two samples of each 100 ml volume of mine water (pH 2.54) taken in two containers viz. flask. Both containers are separately added with 10 gm of overburden and fly ash. The readings of pH value were taken with respect to time. According to the above data graphs (pH vs. Time of Interaction) were plotted.

It can be concluded from the figure 4 and 5 that the rate of change of pH with respect to time is changed after mixing the Flyashand overburden (sandstones) into the acidic water.

Table-5: Texture Analysis of Overburden

Grain Size Analysis of O/B Sample {Sieve Size (mm)}
4.75
2
1
0.425
0.212
0.15
0.075

Fig.-2: Overburden rocks separate from different size of sieves in department mineral crushing laboratory

Fig.-3: Sample preparation in laboratory

RESULTS AND DISCUSSION

It can also be observed from Fig.-4 that the increase in pH value of acidic water (2.54) increases while it is following through after putting the overburden (white sandstone) in acidic water. The range of pH is increased from initial 2.54 to 2.89 after traveling no of times. The pH is increased from figure 4 the pH value after 0 minutes at 10 min is 2.54, at 30 min 2.55 at 12 hours 2.59 at 24 hours 2.69 at 36 hours 2.81 at 48 hours 2.89. Indicates that the rate of increase in pH with reference to increasing time.

It can also be observed from Fig.-5 that the increase in pH of acidic water (2.54) after putting Flyash in acidic water. The range of pH is increased from 2.54 to 3.69. The range of pH is varying from 2.54 to 3.69 after traveling no of times. The pH is increased from Fig.-5 the pH value after 0 minutes at 10 min is 2.58, at 30 min 2.65 at 12 hours 3.04 at 24 hours 3.22 at 36 hours 3.34 at 48 hours 3.69. Indicates that the rate of increase in pH with reference to increase with time.

CONCLUSION

Acid mine drainage (AMD) is widely recognized as the single largest environmental issues faced by the global mining industry. Fortunately, this problem is less common in India. Successful management of acid water drainage can play a significant role in improving the ecosystem, them the environment surrounding as well as the long-term sustainability of mine site.

In this paper, an attempt, therefore, has been made to suggest mitigation measures and the ways how to manage the pollutants in a way so that the ecosystem of the area gets least disturbed by the associated mining activity. The laboratory investigation of the R-pH value of overburden indicates that the overburden (sandstone) is alkaline in nature. We can say that the O/B can be used for acid water treatment. Flyash and O/B (sandstone) both are appreciable neutralization potential and may effectively be used for acid neutralization.

The use of Flyash and waste rock will further improve the gainful utilization of Flyash and O/B for improvement in water quality also. The above study on laboratory scale suggests that the acid neutralizing property of Flyash and O/B will be an asset for coal mines suffering from slight to moderate acid drainage problem both at exploitation and abandoned stages.

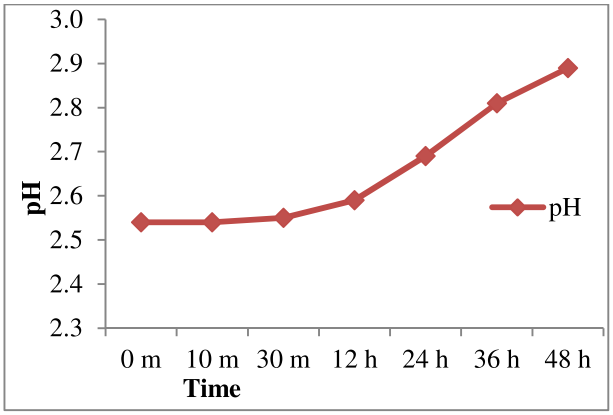

Fig.-4: Time v/s pH value of acidic water putting overburden

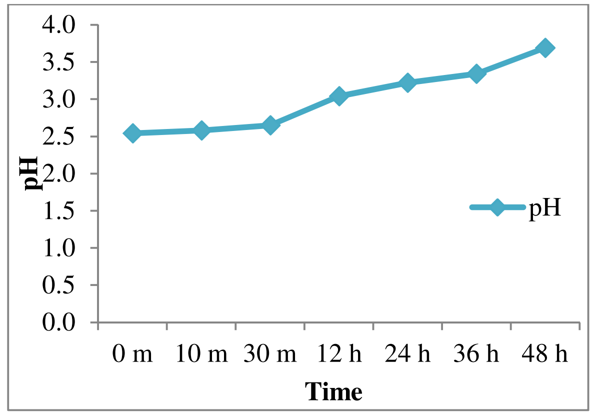

Fig.-5: Time v/s pH value of acidic water putting fly ash

Suggestions for Future Work

The acidic water in the sump of abandoned mines may be neutralized by dumping of alkaline overburden (mainly sandstone) and Flyash to retard the groundwater pollution problem by infiltration of acid drainage.

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