CHAPTER 1

INTRODUCTION

1.1 General

One of the major challenges being faced by the coal mining industry is the disposal and treatment of mine water during and after the closure of a mine. The pollution of surface water by acid mine drainage and mine effluents have serious environmental implication in and around coal mining complex (Jamal et al., 2008). The reuse of water is complicated due to their bulk amount and by the presence of leachates which require long term management and treatment. Characterization of coal mine wastes for the sake of backfilling in mines is very much essential in terms of environment and safety, technological availability and economic feasibility. The impact of backfilling on the water quality in the mining regions also needs attention in order to understand its long-term impact and accordingly to plan remedial measures.

1.2 Overburden

Overburden is removed during surface mining, but is typically not contaminated with toxic components and may be used to restore an exhausted mining site to a semblance of its appearance before mining began. The waste rock from an unstable hillock in and around the coal mines and responsible for varied environmental, aesthetic and social problems. It affects and disrupts agriculture, transportation routes, water supply and water retention capacity of surface water bodies, air, water, and soil pollution and lower the aesthetic of the region (Jamal et al., 2008; Singh and Sinha, 1990). In some coalfield, backfilling is done mainly with overburden and parting materials. It has been observed that the quantity of flyash and waste generated very much from thermal power and mines. Utilization of flyash from various nearby industries can be utilized in addition to overburden as mixing of flyash in backfilling. Optimum quantity in certain cases increases the stability of backfilled materials due to its pozzolanic nature. Currently, the backfilling of the voids is carried out by the waste materials produced during mining of coal. Most of the time, the waste generated from the mines such as sandstone, shales, clay etc. are used for this purpose. At few places in mines, it has been observed that the quantity of the waste generated is not sufficient to fill the voids. Therefore, fly ash generated from the thermal power plants may be used as an alternative backfilling material. Mining and its subsequent activities have been found to degrade the land to a significant extent. Overburden removal from the mine area results in a significant loss of forest and the rich topsoil. Overburden removal is normally done by the process of drilling and blasting, which results in the generation of a large volume of waste (rock debris and other material). A few opencast mines are not backfilled after the exhaust of properly, so large voids are present in the form of abandoned mine.

1.3 Flyash

Further, the flyash produced from the thermal power plant is also a major problem of concerned as far as disposal of flyash. Fly ash generation has increased from 85 million tonnes in the year 2000-01 to 196.44 million tonnes in 2017-18. The percentage of utilization of fly ash has also increased from 20% to 67.13% for the same years. Though, the percentage utilization of the ash has increased over the years; but the quantity of the unutilized flyash is also increasing every year because of the increased generation. Government of India has taken several measures to convert this waste material to useful material through development and application of new technologies and made strict laws for 100 % utilization of fly ash, despite that the fly ash utilization has reached to only 67.13% in the year 2017-18. On discerning the environmental challenges that are posed by the fly ash, the Government of India has taken several initiatives to achieve 100 % utilization of fly ash. In 1994, a technology project in the form of a mission (Fly Ash Mission) was commissioned as a joint activity of Department of Science and Technology, Ministry of Power and Ministry of Environment and Forests for the development and application of the technology for utilization of fly ash in various areas. Ministry of Environment Forest, Climate Change issued a notification to protect the environment, conserve the topsoil and to prevent the dumping and disposal of fly ash discharged from coal and lignite based thermal power plants on land.

1.4 Mine water

Mine water in coal mines is a common problem and its availability increases with depth. As a result of mining, both quality and quantity of water are severely affected. However, mines are always a constant source of contaminants. As a result of variation in geology and mineralogy of coal and associated rocks from mine to mine, a wide variation in the quality of water occurs. The pH of water ranges from acidic to alkaline in nature (Dhar et al., 1987).

Among the objectionable parameters of water quality are low pH value, high level of sulfate, iron and total dissolved solids. These parameters deplete oxygen content in water, increase the toxicity by 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 pumping from mine to disposal sites. Such problems are common with metal sulphides mines also. Acid water from coal mines is a serious issue in the 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. Another important point to be considered is that the coal is the sedimentary deposited and associated rocks (sandstones) which are a good aquifer and accumulate a huge quantity of groundwater. During mining, such groundwater seeped into mine and is being discharged continuously depending upon, the life of the mine. The utilization of mine wastewater can be done only after proper treatment. Various attempts are being made globally to mitigate and conserve the water quality in and around the mine by professionals and researchers.

1.5 Occurrence of acid mine drainage

In coal mines, the main cause of acidity is the occurrence of pyrite and other sulphides metals in the form of a vein, granular and crystallized form in coal and shale (Jamal A, 2015). Release of acid mine drainage (AMD) have low pH, high specific conductivity, high concentrations of iron, aluminium, and manganese, and high concentrations of toxic heavy metals. Because most treatment technologies are either inadequate or too expensive, quite commonly, significant AMD is left untreated. The reactions of acid generation are best illustrated by examining the oxidation of pyrite (FeS_2), which is one of the most common sulfide minerals.

The first important reaction is the oxidation of the sulfide mineral into dissolved iron, sulfate and hydrogen:

$$FeS_2 + 7/2\ O_2 + H_2O - Fe^{2+} + 2SO_4^{2-} + 2H^+ \text{ …….. (1)}$$

The dissolved $Fe2^+$, $SO_4^{\ 2-}$ and H^+ represent an increase in the total dissolved solids and acidity of the water and, unless neutralized, induce a decrease in pH. If the surrounding environment is sufficiently oxidizing (dependent on O_2 concentration, pH and bacterial activity), much of the ferrous iron will oxidize to ferric iron, according to the following reaction:

$$Fe^{2+} + 1/4\ O_2 + H^+ - Fe3^+ + 1/2\ H_2O \text{ …… (2)}$$

At pH values between 2.3 and 3.5, ferric iron precipitates as Fe $(OH)_3$ and leaving little Fe^{3+} in solution while simultaneously lowering pH:

$$Fe^{3+} + 3H_2O - Fe\ (OH)_3 \text{ solid} + 3H^+ \text{ …..(3)}$$

Any Fe^{3+} from Eq. (2) that does not precipitate from solution through Eq. (3) may be used to oxidize additional pyrite, according to the following:

$$FeS_2 + 14Fe^{3+} + 8H_2O - 15Fe^{2+} + 2SO_4^{2-} + 16H^+ \text{ …..(4)}$$

Based on these simplified basic reactions, acid generation that produces iron which eventually precipitates as $Fe(OH)_3$ may be represented by a combination of Eqs. (1)-(3):

$$FeS_2 + 15/4O_2 + 7/2H_2O - Fe\ (OH)_3 + 2SO_4^{2-} + 4H^+ \text{ ……(5)}$$

On the other hand, the overall equation for stable ferric iron that is used to oxidize additional pyrite (combinations of Eqs. (1) - (3)) is:

$$FeS_2 + 15/8O_2 + 13/2Fe^{3+} + 17/4H_2O - 15/2Fe^{2+} + 2SO_4^{\ 2-} + 17/2H^+ \text{ ….(6)}$$

All of the above equations, with the exception of Eqs. (2) and (3), assume that the oxidized mineral is pyrite and the oxidant is oxygen. However, other sulfide minerals such as pyrrhotite (FeS) and chalcocite (Cu_2S) have other ratios of metal sulfide and metals other than iron. Additional oxidants and sulfide minerals have different reaction pathways, stoichiometries and rates, but research on these variations is limited. In many environmental settings, the consequence of AMD is considered moderate to severe, mostly independent of pH and acidity (Akcil and Koldas, 2006, Jamal et al., 1991).

1.6 Statement of the problem

One of the most serious water pollutions associated with some of the coal mines is the of AMD. In all coal sulfur is almost always associated with coal, both inorganic and inorganic forms. The occurrence of inorganic sulphur in coal, mostly in the form of pyrite is the main cause of AMD. If AMD is left uncontrolled and untreated, the drainage contaminated local water courses and groundwater, damage the health of mine machinery and biotic life. Under the present scenario disposal of such water is not permitted. Flyash is produced in large quantities by combustion of coal in power plants. Overburden is produced in high volume after excavated coal from the mine and stripping ratio is ranging from 1 to 4.5 in this subsidiary. These are also a nuisance for the environmental. Use of flyash and overburden for neutralization of AMD is not only solving the problem of acidic water but also providing an opportunity for further uses of flyash in coalmines. Hence a detailed investigation of mine water, overburden and flyash has been conduct to fill overburden mixed flyash in active and abandoned mines.

An abandoned mine is mine or quarry, which is no longer producing coal or not in working conditions. These abandoned mine present serious threats to human health and the environmental. There is an abandoned coal mine in NCL having acidic water (pH 2.54) Gorbi Mine in Northern Coalfield, Singrauli. The Gorbi mine has three abandoned mine pits i.e. Pit I, Pit II & Pit III. The abandoned areas are partly backfilled with OB material is covered by moderately grown tall trees and bushes. The region is a sedimentary terrain with good groundwater potentialities and characterized by high porosity and permeability.

1.7 Application of the study

One of the major environmental challenges is to manage the huge volume of overburden generated, in these opencast mines since it is associated with the problems of landslides, loss of topsoil, soil erosion, water and air pollution, ecological disruption and social problem etc. Also, the overburden is heterogeneous and consists of alluvium, laterite, sandstone, carbonaceous shale, coal bands, clay between coarse to medium-grained ferruginous sandstone etc. These mines are facing problems due to unscientific backfilling without consideration of the geochemical assessment of the OB material. Singrauli coalfields are also facing such environmental problems. The field application of this work is to classify different rock units associated with coal, according to their acid generating potential for effective environmental management in and around the mines. Based on this information can be made with respect to specific mitigation measures for proposed mines at one place and suggesting appropriate treatment technique for Acid Mine Drainage (AMD) Management in another place.

1.8 Objective of the work

The basis of this work, there are an abandoned and some active coal mine of Northern Coalfield, Singrauli, which has acidic, neutral, and alkaline water. The proposed plan is to treat to very acidic water of Gorbi mine, which is abandoned for more than 20 years. It is not in a position to handover to state Government. Though this study suggestion will be given to to fill the abandoned voids by mixed disposal of overburden and flyash. The detail investigation of mixed OB and flyash have been carried out on the laboratory scale to investigated different properties of overburden, flyash, and mixed overburden + 30% flyash. The quality of water in the proposed mine is highly acidic in nature. Requires the treatment of mine water for minimum impact on the aquatic life and receiving the stream.

The objective of this thesis work was to investigate the suitability of overburden and flyash to be filled in mines and assess its impact on water quality.

To assess the impact of overburden, flyash and mixed disposal overburden and flyash in voids of opencast coal mines on the quality of water leached. Following question will be answered.

1. What would be the leachate characteristics in mine sump water & subsequent seepage over the surface and below the surface

A. To assess the impact of overburden on water quality:

   a. When water in mine is acidic

   b. When water in mine is alkaline

B. To assess the impact of flyash on water quality:

   a. When water in mine is acidic

   b. When water in mine is alkaline

C. To assess the cumulative impact of mixed disposal (overburden and flyash) on water quality:

   a. When water in mine is acidic

   b. When water in mine is alkaline

2. To assess the suitability for the dumping of overburden with flyash disposal in voids of coal mine to minimize the impact of water and land resources

3. Characterization of overburden and flyash material based on their chemical, mineralogical properties for their use in mines as filling material

1.9 Organisation of the chapters

The report presented in this thesis is primarily comprised of five chapters and a summary of each chapter is as given below:

Chapter 1 presented the current scenario of coal mining in the opencast coal mines of Northern Coalfields Limited (NCL). The problem of overburden and flyash are discussed. The background and motivation together with the aim and objective of the research work is also presented.

Chapter 2 Present the summary of the earlier research finding on backfilling A in opencast mines. Discussed the production of flyash and overburden in Singrauli coalfield.

Chapter 3 the detailed status of the study area and their characteristics such as geology, topography, hydrology and drainage pattern. Overburden and water samples are collected from NCL, mines. Flyash sample collected from various thermal power plants of Singrauli Coalfield. States the collection, preservation, and applied instrumentation was discussed in this chapter. Water quality of mines and different location of ground water is discussed.

Chapter 4 presented the detailed analysis of the results and discussions. The water samples are analyzed for their physical, chemical properties as per the standard methods prescribed in Indian drinking water standard guidelines. Included mineralogy studies such as soil quality (Flyash, overburden, and overburden + flyash) analysis and leachate analysis study of the filling materials have been discussed. The methodology adopted for determination of physicochemical, mineralogy and geochemical properties for mine water, overburden and flyash materials along with their results. A case study discussed in this chapter.

Chapter 5 presented the detail of the conclusions, suggestions for future scope.

At the end, list of references that have been used for carrying out this research work is attached along with published work.