Assessment and Management of Abandoned Coal Mine to Neutralize Acid Mine Drainage

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Abstract - *One of the most significant water risks posed by mining is acid mine drainage. A mine draining acid may wreak havoc on rivers, streams, and aquatic life for hundreds, if not thousands, of years. It might simply be compared to the well-known air pollution problem. Acid rain is a pollution-related issue. Acid rain is caused by atmospheric SO2 interacting with water. Sulfuric acid is made from H2O. Similarly, when sulphur is present in the form of sulphide minerals in rocks, When sulfuric acid is freed and oxidised, it produces sulfuric acid. A case study (Gorbi abandoned mine NCL Singrauli coalfield) was conducted for this thesis. Evaluation and control of corrosive mine water in an abandoned mine hole filled with water that is acidic has been explored. Examining the acid neutralization capabilities of fly ash and O/B for acid water treatment as well as other water quality metrics such as TDS and PH using fly ash, waste rock materials, and acidic water collected in the field. Due to the constraints imposed by Covid-19, I ran a few tests at home, based mostly on a literature analysis of numerous research, to establish the best probable strategy for acid water regulation. The findings are positive, indicating that both fly ash and overburden (sandstone) have high neutralisation potential that might be effective for efficiently neutralizing mine acid water.*

***Key Words*: Acid Mine Drainage, Fly Ash, Neutralization**

1. INTRODUCTION

Due to a prolonged investment programme and a higher emphasis on the utilisation of current technologies, Coal India Limited was able to boost coal output in India to 730.87 million tonnes in 2019-20. In 2020-21, India's total coal mining production was 716.01 million tonnes, a negative growth rate of -2.03 percent. The main coal producers in India are Coal India Limited (CIL) and its subsidiaries. India is the world's third largest producer of electricity and third greatest user. As of May 31, 2021, India's national electric grid has an installed capacity of 383.37 Gigawatt. Renewable energy plants, including big hydropower plants, account for 37% of India's total installed capacity. The disposal and treatment of mine water during and after the closing of open cast mines is one of the primary difficulties that the coal mining industry is now experiencing. Surface water pollution by acid has wreaked havoc on the ecology in and around coal mining sites (Jamal et al., 2008). The huge amount of water and the presence of leachates hamper water reuse, necessitating long-term management and treatment. For environmental and safety considerations, technical availability and the mines economic viability, characterization of coalmine wastes for backfilling in mines is crucial. The long-term impact of overburden mixed fly ash dumping on water quality in mining zones must also be considered in order to develop appropriate corrective measures.

1.1 Acid Mine Drainage

Before AMD is the product of atmospheric (i.e., water, oxygen, and carbon dioxide) oxidation of relatively common iron-sulfur minerals like pyrite (FeS_2) and pyrrhotite (FeS) in the catalysing presence of Acidithiobacillus ferrooxidans, an acidophilic bacterium, as well as the other products generated as a result of those oxidation reactions. Contaminated drinks, disturbed development and reproduction of aquatic plants and animals, and consequently the acid's corrosive effects on infrastructure components such as bridges are all problems linked with mine drainage. Traditional AMD therapies include a number of physicochemical approaches. Biological therapy for AMD has emerged as a viable, cost-effective, and ecologically friendly approach. The bulk of these techniques rely on microorganisms like bacteria and fungus to perform passive cleanup. Microbial bioreactors and wetlands

Metals and sulphates are reduced, and 14 alkalinity is produced, which helps to minimise AMD. Biotechnological methods can aid in the development of ways for efficiently treating wastes like AMD without jeopardizing environmental sustainability. Acidity, ferric ion (Fe^{3+}) precipitation, oxygen depletion, and the discharge of heavy metals from coal and metal mining, such as aluminium (Al^{3+}), zinc (Zn^{2+}), and manganese (Mn^{2+}), have all had an influence on stream and river ecosystems. Acid mine drainage must be able to feed sulfide-containing mineral resources when they are exploited. Coal, copper, gold, silver, zinc, lead, and uranium mining are all examples of this. Pyrite, popularly known as "fool's gold," is a sulphide mineral (FeS_2). One of the most significant sulphides found in mine waste rock is pyrite. When exposed to water and oxygen, it can form vitriol (H_2SO_4).

1.2 Fly Ash

Many pithead thermal power plants utilise ash to restore abandoned coal pit voids. is frequently this is one of the sites where a considerable volume of ash produced by pithead and distantly located power plants may be used on a lengthy basis. Coal mining pits are typically developed land for afforestation and other uses. However, only around 6 percent of the total of the total capacity is now being utilised. At least 25% ash is commonly combined with Overburden waste for filling inside coal mines and other metal ore mines, according to the regulations of the MoEF and CC gazette notice. Coal India Limited (CIL) and the Ministry of Coal (MoC) do not permit the mixing of ash with overburden material and filling in running coal pits due to mine safety issues. In abandoned mining voids, CIL and MoC, but in the other hand, allow ash backfilling. The Ministry of Power has organised a task force with members from several stakeholder groups to discover abandoned mine pit voids and other mineral and metal mines so that they may be sent to thermal power plants for backfilling with ash. To 36 take over ash backfilling, thermal power units will be deployed to the identified mining voids. The CPCB has also created guidelines/standard procedure (SOP) to guarantee that ash fills are administered in an environmentally friendly way at thermal power plants.

1.3 Overburden

Overburden classification is crucial for mining planning and environmental concerns. Overburden classification has been applied to the detection of extremely acidic "noxious" chemicals. The overburden study also includes information on the ability to discharge TDS and Se. Overburden management necessitates consideration of both chemical and physical characteristics. Subsurface drainage infrastructure require hard, long-lasting rock. Topsoil alternatives, if approved, should exhibit chemical and physical properties that are suitable for post-mining land usage. Acid-resistant materials should be identified on any overburden materials proposed for installation in locations exposed to environmental waters. 36 assume responsibility for ash backfilling. The CPCB has also created guidelines/standard procedure (SOP) to guarantee that ash fills are administered in an environmentally friendly way at thermal power plants. One of the most dangerous waterborne pollutants from coal mining operations is the acid created by the exposure of iron sulphide minerals found in coal and overburden. As a result of the acid's direct impact on the stream and the degradation of concrete, other ions, such as heavy metals, get solubilized and flow into water channels. When overburden is removed, pyrite (iron disulfide)-bearing rock is frequently exposed (iron disulfide). During the oxidation of pyrite (FeS2), ferrous iron and sulfuric acid are produced. A further reaction produces ferric hydroxide and additional acid.

1.3 Mixing Of Ash In External Overburden Dumps

Another important way to use fly ash for pit head power stations in the Singrauli area is to mix 25% ash in external overburden dumps of operating opencast mines on a volume-to-volume basis, as per the MoEF & CC's ash notice. Northern Coalfields Limited produced 101.50 MT of coal in the 2018-19 fiscal year. During the year, roughly 400 MT of overburden were generated using a 1:4 stripping ratio. As a result, NCL coal mines' overburden dumps have the ability to consume about 80 million tonnes of ash each year. NTPC Vindhyachal generates around 08 million tonnes of ash per year, which accounts for about 2.5 percent of all OB generated.

2. METHODS

2.1 Mixing Of Ash In External Overburden Dumps

The Gorbi abandoned mine in NCL, Singrauli District, Madhya Pradesh, India, provided acidic mine water samples. A considerable volume of water has grown corrosive at this abandoned mining site. Earlier plans to backfill Coal Fly Ash generated at NTPC thermal power stations in Singrauli using the abandoned mine gap at Gorbi were scrapped because to fears of AMD overflow causing environmental harm (pH 2.4). The water samples were taken in pre-treated sampling vials. Because plastic jugs are lightweight, inorganically inactive, and long lasting, they were chosen as the container. All of the water samples were examined using the department's regular methodologies. In Madhya Pradesh's Singrauli area, fly ash samples were gathered from the nearby NTPC Vindhyachal Super Thermal Power Project. This project is in the Singrauli region, some 225 kilometres south of Varanasi, on the Madhya Pradesh-Uttar Pradesh interstate boundary. Gunny bags made of strong poly-coated cotton were used to collect dry fly ash. A massive amount of overburden was recovered after the top soil was removed from the Singrauli coalfields' overburden dumps. Overburden samples were taken from 10 different mines. The overburden rocks in the research region are friable, loose, and non-cohesive, with sizes ranging from boulders to small clay components.

An XRF spectrometer is used for regular chemical studies of rocks, minerals, sediments, and fluids. The formation rock samples were crushed and pulverised to roughly 5 microns in size, then transformed into pressed pellets with binder for XRF analysis using an energy dispersive XRF spectrophotometer. The concentrations of elements are calculated using a quality calibration curve and reported in their oxide form.

2.2 Water Quality Analysis

An Electrode Probe on a Multi-Parameter Analyzer may measure up to ten parameters at simultaneously, including pH, Conductivity, TDS, Turbidity, DO, ORP, Salinity, Temperature, and pH. This metre contains a one-of-a-kind control unit and water analysis sensor technology. Water was used to clean the sensor after it was properly checked. There was just one measurement choice specified.

After that, the sensor was submerged in water to confirm that no air bubbles developed around it. After the readings had stabilised, the data were recorded and tabulated. In the laboratory, other chemical properties 52 such sulphate and chloride, as well as metals like Fe, Na, Ca, K, and Mn, were examined.

3. RESULTS AND DISCUSSIONS

Fly ash particles are extremely tiny, low in weight (density 1.97-2.89 g/cc), spherical (specific surface area 4000-10,000 cm2 /g; diameter 1-150), refractory, and pozzolanic. The colour of fly ash varies from grey to blackish grey, depending on the coal type and combustion procedure. Fly ash has a dielectric constant of 104, making it suitable for electronic applications.

3.1 Characterization of Fly ash

Chemical composition of fly ash (XRF)

Table: Major and trace elements in the fly ash obtained by XRF

Sr. No	XRF analysis data of fly ash com Composition	Percentage
1	SiO2	59.71%
2	Al2O3	21.07%
3	CaO	5.48%
4	FeO	9.87%
5	MgO	2.13%
6	MnO	0.42%
7	Na^2O	0.83%
8	K_2O	0.48%

Elemental Composition Analysis

Table Elemental analysis of fly ash

Element	Weight %	Atomic %
C K	20.13	28.74
O K	49.97	53.55
Na K	0.04	0.03
Mg K	0.21	0.15
Al K	9.53	6.05
Si K	16.42	10.02
P K	0.59	0.33
S K	0.05	0.03
K K	0.48	0.21
Ca K	0.4	0.17
Ti K	0.93	0.33
Fe K	1.27	0.39
Total	**100.00**	**100.00**

3.2 Acid Neutralization Potential of Solid Waste

The chemical composition of AMD varies widely depending on its source, whereas the mineralogy of the source parent coal and, as a result, the power plant from which it was extracted determines the chemical composition of FA. Only the neutralisation of low pH, Fe and Al-rich AMD from a single coal mine and ash from a single power station was investigated. Mpumalanga is a South African province. AMD was gathered from a number of coal mines. FA was successfully treated from a number of power facilities. The pH shift and EC over time for various AMD and FA combinations were determined using open beaker testing.

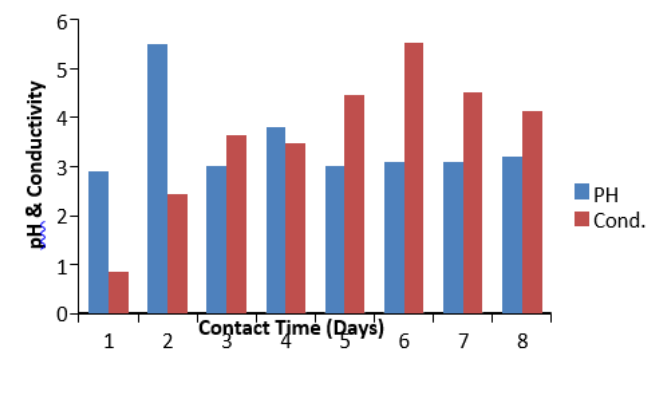
Laboratory research was conducted. According to the protocol, a known mass of FA was introduced to the beaker. The AMD: FA mixture ratio, for example, is required for a 1:1 (AMD: FA) ratio. 4000 cc ash was added to 4000 ml AMD. A distillation procedure was used on the pit water sample. EC was determined at various time intervals with a portable pH metre and a calibrated pH.

Fig. Analysis of fly ash on acidic water and noting down the measurements

Fig. Experiment showing collection of water sample into cylinder.

Analysis of mine water was done with different mixtures of fly ash and Overburden for one week and the results obtained were compared through graphical representation.

4000cc FA + 4.0L pit water



Fig; Graph of PH and conductivity of (FA)

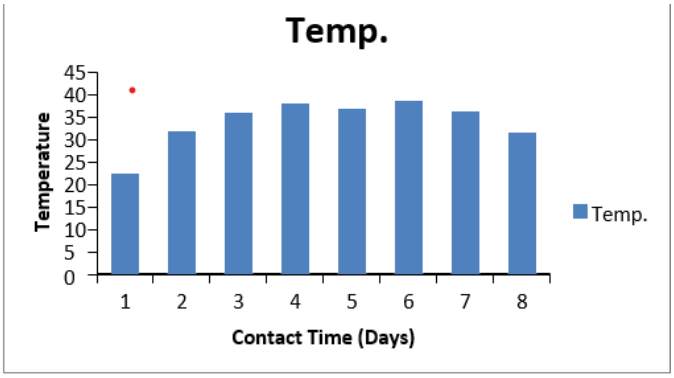


Fig: Graph of Temperature of (FA)

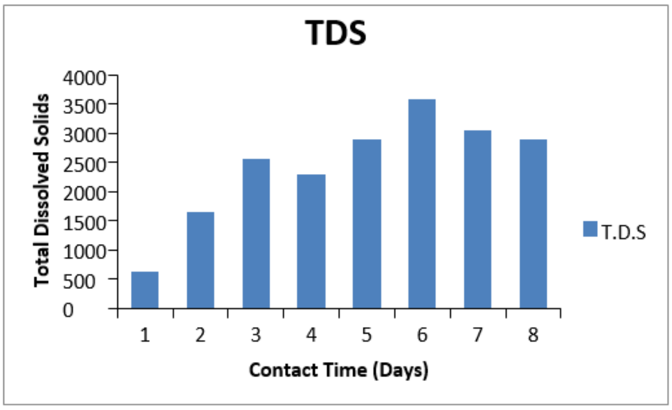


Fig: Graph of T.D.S. of (FA)

In the second experiment we are taking equal amounts of Fly Ash and Overburden materialto add into 4 Liters of pit water in the ratio 1:1:2 (FA+OB+AMD). As you can see this mixture was more useful in bringing the PH to neutral side.

2000cc FA +2000cc OB + 4L pit water

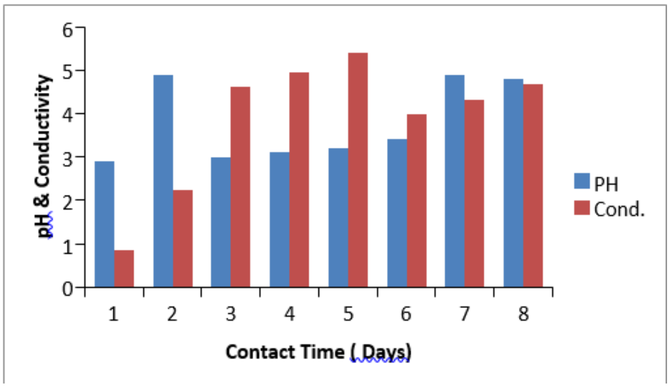


Fig: Graph of pH and conductivity of (FA+AMD)

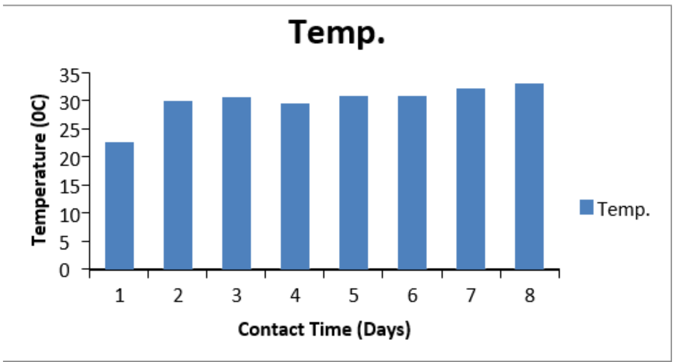


Fig: Graph of Temperature v/s Contact time (FA+AMD)

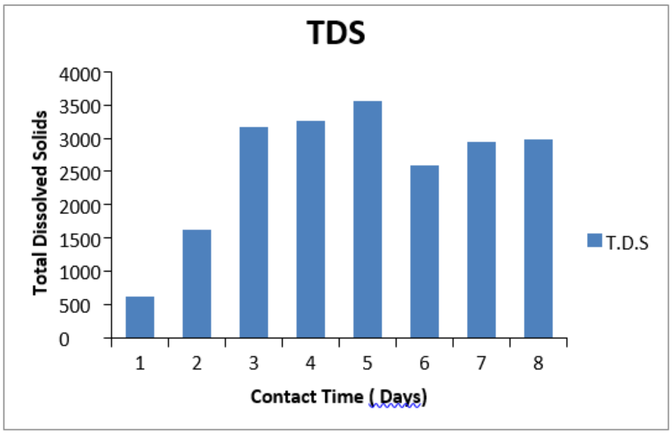


Fig: Graph of T.D.S. of (FA+AMD)

3.3 Batch Experiment

In this method, the waste material is added to pit water from above and then kept in a bucket and reading is taken accordingly.

4000cc FA + 4.0L pit water

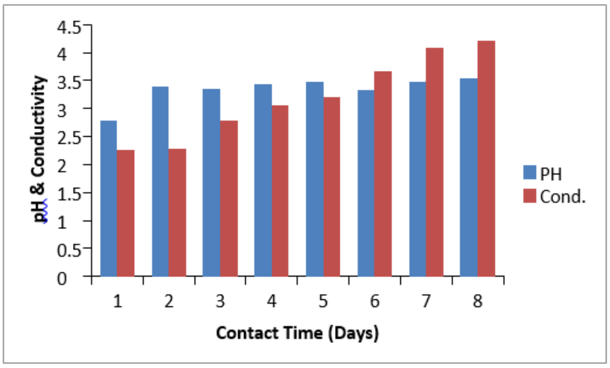


Fig: Graph of PH and conductivity of (FA+AMD)

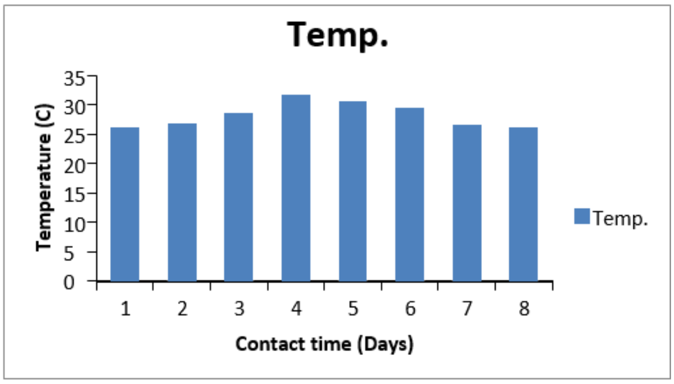


Fig: Graph of Temperature of (FA+AMD)

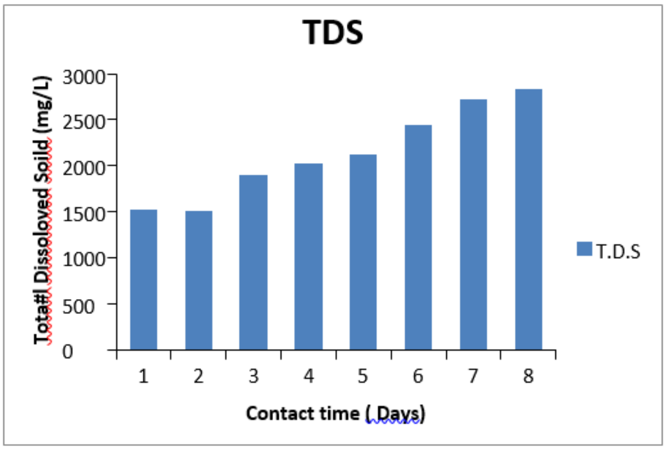


Fig: Graph of T.D.S. of (FA+AMD)

4000cc OB +4L Water

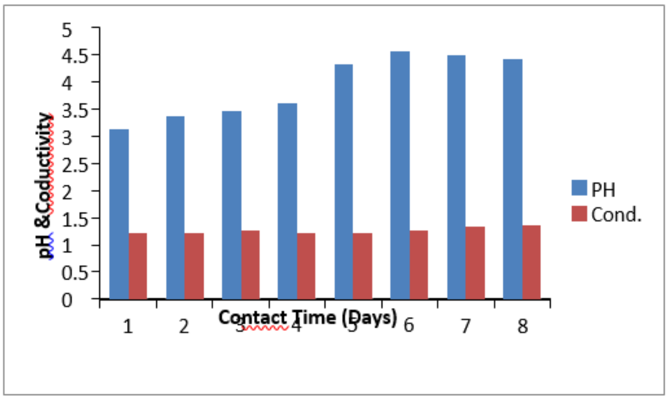


Fig: Graph of PH and conductivity of (OB+AMD)

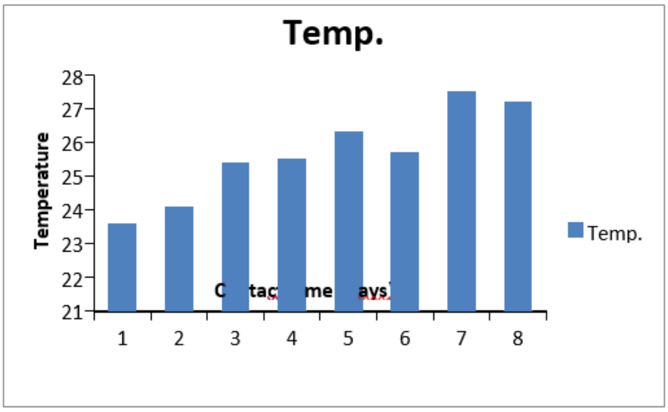


Fig: Graph of Temperature of (OB+AMD)

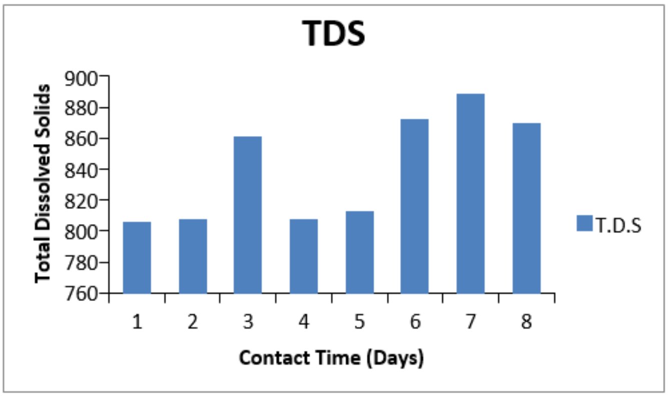


Fig: Graph of T.D.S. (OB+AMD)

4. CONCLUSION

In this study laboratory investigation carried out to assess suitability of best material for filling mine voids of abandoned mine having highly acidic water and to neutralize acid mine drainage. As a result of laboratory investigation, following conclusions have been drawn:-

When crushed overburden, fly ash, and mix material (fly ash + overburden) are allowedto interact with acidic mine water, the results show an increase in pH value as well as a decrease in TDS and electric conductivity. The findings also reveal that a mixture of fly ash and overburden is more effective in neutralising acidic water.

The influence of fly ash mixed overburden disposal on water quality is positive, as the results reveal that both the overburden and fly ash have high neutralising capability for reducing the acidity of mine water. As a result, this material can be employed as a backfilling material in abandoned mines.

The results also conclude that for the neutralization of acidic mine water (4L), we need same amount of coal fly ash i.e. 4.0kg.

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