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Metal Removal from Acid Mine Water by using the SAPS

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***Abstract:** Mining activity different types of problems may arise from physical hazard to pollution of water and soil. Most severe problem arises with water. The acid mine water represent a reason of potential hazard to the surrounding environment, particularly when the wastes are containing sulphide minerals that will oxidize and generate acid mine drainage (AMD) in mines. Acid mine drainage (AMD) by which it is caused by leaching, seepage or drainage that is affected by the oxidation of sulfide mineral rocks when exposed to the air and water. The system of Successive Alkalinity Producing System (SAPS) is very effective and easily removal of metals like Iron, Manganese and Aluminum etc. The vertical flow anaerobic wetlands have been developed. In them, mine water is forced to follow a vertical circulation, which has been proved to be more efficient in the treatment techniques. In this has been made to explore the possibility of effective removal of metal from AMD.*
***Keywords:** Acid Mine Drainage (AMD), Successive Alkalinity Producing System (SAPS), Organic substrate, Hydraulic retention time (HRT), and Bacteria activity.*

I. INTRODUCTION

The Acid mine water is a worldwide problem closely associated with abandoned as well as active mines. Iron, copper and Uranium mine are the major cuprites of AMD formation. Prerequisite condition for formation of AMD to take place is presence of sulphide bearing rock i.e. ferrous sulphide in surrounding country rock or in ore deposit itself.

Mining activity exposes these sulphides bearing rock for oxidation in presence of oxygen in open environment. Oxidation of sulphide followed by further hydrolysis (addition of water) results in formation of acid mine drainage. So AMD is caused when water flows through sulfur bearing materials forming solutions of acidity. The oxidation and hydrolysis of sulphide bearing materials ultimately produces enough quantity of sulfuric acid to lower the pH of water.

The low pH value of discharge mine water results in release of toxic metals when it is allowed to be discharged into other water bodies.

This acidity and high toxic metals concentration are very harmful to the vegetation and aquatic life. The amount of AMD produced depends on the size of the exposed surface area of in the presence of sulphide minerals.

Acid Mine water represent a reason of potential hazard to the surrounding environment, particularly when the wastes are containing sulphide minerals that will oxidize and generate acid mine drainage (AMD) in mines.

Acid mine drainage (AMD) by which it is caused by leaching, seepage or drainage that is affected by the oxidation of sulfide mineral rocks when exposed to the air and water. Mine sites the issue impact of AMD the management of AMD wastes is a major environmental issue for mining industries. Major costs may arise after closure of the mine if proper waste management strategies are not started from the beginning of mine operations.

II. LITERATURE REVIEW

The wetland treatment system effectiveness has been limited by the alkalinity producing or acidity neutralizing capabilities of the systems. Successive Alkalinity Producing Systems (SAPS) combine ALD technology with sulfate reduction mechanisms. SAPS promote to vertical flow through rich organic wetland substrates into limestone beds beneath the organic compost discharging the pore waters. (Kepler Douglas A et.al and McCleary Eric C et.al, 1994)

Acid mine water is a serious problem in many watersheds where coal is mined. A new treatment technique is a vertical flow wetland and Successive Alkalinity Producing System (SAPS). (J.Demchaket.al)

The Successive Alkalinity Producing System (SAPS) for acid mine drainage treatment, spent mushroom or cow dung as organic substrate as used as immobilizing and nutrient source for sulfate reducing bacteria (Young Wook Cheong et.al).

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A. Formation of Acid Mine Water

The AMD generation is a combined like chemical and biological process. AMD occurs when sulfides particularly pyrite and pyrrhotite are exposed to water and oxygen and reaction are catalyzed by aerobic bacteria such as Acidithiobacillus formerly Thiobacillus (Zagury et.al, 1997). The oxidation of iron sulphide, pyrite is the primary mechanism by which acid is released into mine drainage. The process is initiated by breakdown of the pyrite in the presence of oxygen and water

$$FeS_2 + \frac{7}{2}O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+ \quad (1)$$

When the sufficient oxygen is dissolved in water, the oxidation of ferrous to ferric iron occurs, in the next step. This step is referred to as rate determining step for the overall sequence.

$$Fe^{2+} + \frac{1}{4}O_2 + H^+ \rightarrow Fe^{3+} + \frac{1}{2}H_2O \quad (2)$$

The next step involves hydrolysis of ferric iron to produce the solid ferric hydroxide and the release of additional acidity. This step is pH dependent.

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+ \quad (3)$$

As the next step the acidity increases the reaction re-initiates because ferric iron remains in solution and is reduced by pyrite, resulting in the release of ferrous iron and acidity.

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

The final cyclic propagation of acid generation by ferric iron takes place very rapidly and continues until the supply of ferric iron of pyrite is exhausted.

$$4FeS_2 + 15O_2 + 14H_2O \rightarrow 4Fe(OH)_3 + 8H_2SO_4 \quad (5)$$

$$\text{Pyrite} + \text{Oxygen} + \text{Water} \rightarrow \quad \text{Yellow Boy} + \text{Sulphuric acid}$$

III. METHEDOLOGY

A. Successive Alkalinity Producing System

1) *Introduction*: Ferrous iron is most common and abundant in coalmine drainage. The oxidation and hydrolysis of Ferrous iron is largely considered as having more contribution in acidity, thus it termed as acid mine drainage. The System having limestone layer and organic layer are provided with settling pond. Limestone layer increases alkalinity and organic layer decreases dissolved oxygen, aluminum and also reduces ferric ion to ferrous.
2) *Principle*: The vertical flow increases with contact time. When entering the limestone it adds alkalinity again lowers the dissolved oxygen then further increases alkalinity. Flushing is provided to remove metal concentrations to avoid clogging.
3) *Methodology*: It is basically three units, which is SAPS unit, oxidation and sedimentation units.
4) *SAPS unit*: It is consists cylindrical anaerobic column which is filled with a layer of limestone gravel, a layer of organic substrate(saw dust and cow dung) and above portion filled with AMD water.
5) *Oxidation:* The SAPS effluent allows metal oxide to precipitate and maintains anaerobic environment.
6) *Sedimentation unit:* The water flows in circular path. Bottom is filled with bentonite, which is impermeable clay having ion exchange capacity. The rest of wetland is filled with limestone.
7) *SAPS unit:* Net acidic mine water containing high concentration of ferric iron and aluminum (> 3 mg/L), get neutralize with SAPS or series of SAPS. Passive system generally are consists main components like anaerobic wetland, oxidation and settling pond (Patel et al. 2018).

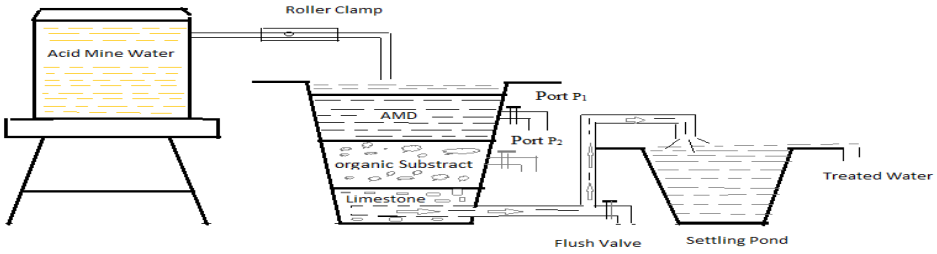

Fig. 1: Laboratory setup SAPS through treatment for Acid Mine Water

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B. Experiment procedure for charging of SAPS

First take all the dimensions of the SAPS, AMD tank and oxidation pond. Take a 200 liters drum and prepare synthetic AMD. According to the standards the SAPS is charged with 27 kg limestone, 6 inch sawdust and 15-20 kg of organic substrate (Cow compost or mushrooms) here we used cow compost as organic substrate.

The AMD tank, SAPS, oxidation pond 1and 2 can be placed one above the in sequence manner in series in a stepped shelf. The purpose of organic substrate is to provide food for sulphate reducing bacteria which generate alkalinity by reducing sulphate to sulphide and remove the dissolved metals.

One of the important functions of organic substrate is to reduce ferric to ferrous ion and eliminate the dissolved oxygen and aluminum from AMD before it enters the limestone layer. The downwards flow increases reaction time between AMD and organic substrate. A flushing system is provided at the bottom of SAPS to flush out the SAPS time to time for avoiding chocking.

Fig. 2: the sequential procedure of charging the SAPS

C. Laboratory Analysis and Calculation

The 10 samples are taken individually in 10 individual glass beakers such that 50 ml of each sample is taken in individual glass beakers. For finding the ferrous ions in the given that sample.

Previously I have taken 10 individual glass beakers in which 50 ml of each sample is to be taken in the glass beaker. Now add 1ml of HCl in every beaker. Same quantity of 1 ml of Hydroxylamine is added in each beaker. Add 2 ml of Ammonium Acetate (Buffer solution) in each beaker. Add 4 ml of Phenolphthalein in each beaker.

The sample should be purified such that filter paper should be kept which removes the impurities. The calculation of the total iron content can be done from the UV Spectrometer.

The UV spectrometer is the instrument used to measure the metal content like iron, aluminium and manganese etc. Introduce wavelength of 510 nm into the UV spectrometer and the total iron content is measured in Abs (Absorbent).

Table 1: Measurement of flow rate and removal of metal

Flow rate (ml/min)	Sample	Absorbance	Concentration	Amount of iron removed (mg/L)
40	P_1	0.806	45.45	54.55
	P_2	0.763	40.90	59.1
20	P_1	0.783	42.72	57.28
	P_2	0.602	32	68
12	P_1	0.576	27.27	72.73
	P_2	0.378	23.63	76.37
8	P_1	0.409	24.54	75.46
	P_2	0.407	23.63	76.37
4	P_1	0.357	19.09	80.91
	P_2	0.314	16.36	83.64

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IV. OBSERVATION & RESULT

A. Metal Removal by SAPS

Treatment of net acidic mine water requires separation of the alkalinity, ferrous removal stages. The alkalinity should be added in an anaerobic environment and then the water exposed to oxygen to enable efficient Fe oxidation. Successful long-term treatment using systems such as SAPS requires ongoing management.

1) From the flow rate 40 ml/min of P_1 sample 54.55 mg/L and P_2 sample 59.1 mg/L of iron is removed.
2) From the next flow rate 20 ml/min of P_1 sample 57.28 mg/ L and P_2 sample 68 mg /L of iron is removed.
3) From the next flow rate 12 ml/min of P_1 sample 72.73 mg/L and P_2 sample 76.37 mg/L of iron is removed.
4) From the next flow rate 8 ml/min of P_1 sample 75.46 mg/L and P_2 sample 76.37 mg/L of iron is removed.
5) From the next flow rate 4 ml/min of P_1 sample 80.91 mg/L and P_2 sample 83.64 mg/L of iron is removed.
6) The Alkalinity increases with increase in the Hydraulic Retention Time. The metal removal increases with increase in HRT.

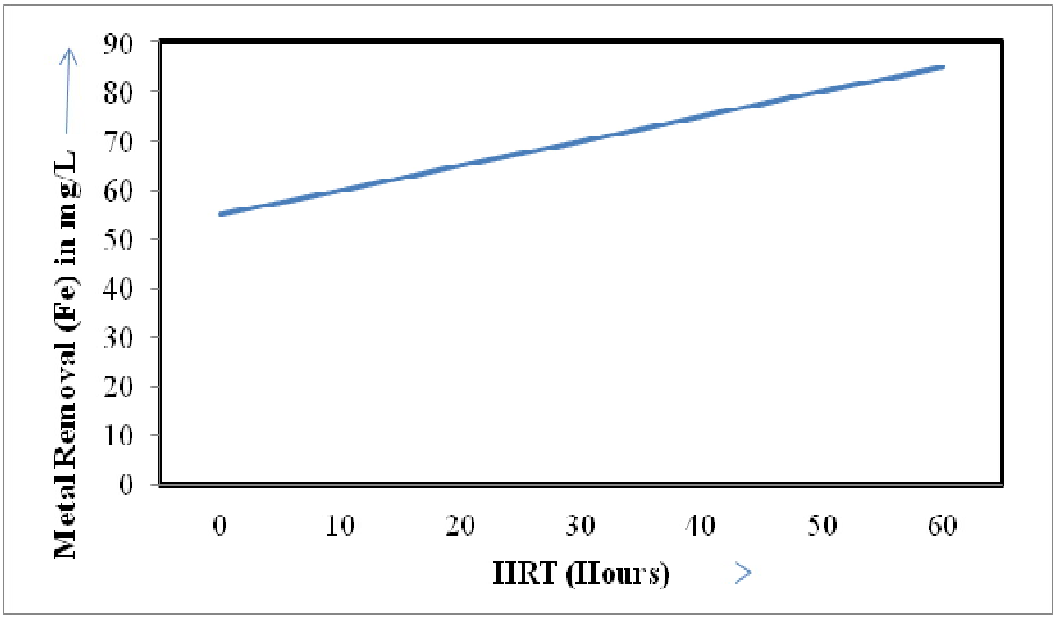

Fig. 3: Relationship between the metal removal and hydraulic retention time (HRT)

7) This is the graph that shows the relationship between the metal removal and retention time. The metal (Fe) removal (mg/L) is represented on Y-axis. The hydraulic retention time (hrs) is represented on the X-axis.
8) This graph gives the amount of metal of iron metal removed within the particular hydraulic retention time. The graph at first increasing and next stage it is constant and after it is going on increasing because the dissolution of limestone and bacterial activity is less when time is going on increasing.

V. CONCLUSION

A. SAPS are very effective in the removal high amount of iron and Alumininum.
B. The alkalinity increases with increase in HRT.
C. SAPS have been found very effective in treating highly acidic and high metal like Fe, Al and Mn.
D. SAPS having benefit of both active and passive system
E. This method used for treatment of AMD they also used for metal removal.
F. Recent trends for AMD control shall be utilized at large scale for proper prevention of AMD generation.
G. SAPS are found very effective in controlling AMD as compared to other conventional methods
H. SAPS utilize the principle of Anaerobic Wet Lands (AWL) and Anoxic Limestone Drains (ALD).
I. SAPS are effective in the less removal of manganese content in water.
J. If one SAPS is not enough for the metal removal more SAPS can be installed in series for more metal removal.
K. The space required for the installation of SAPS is very less. The metal removal increases with increase in HRT.
L. SAPS life is more as compared to other treatments because no armoring of limestone takes place.

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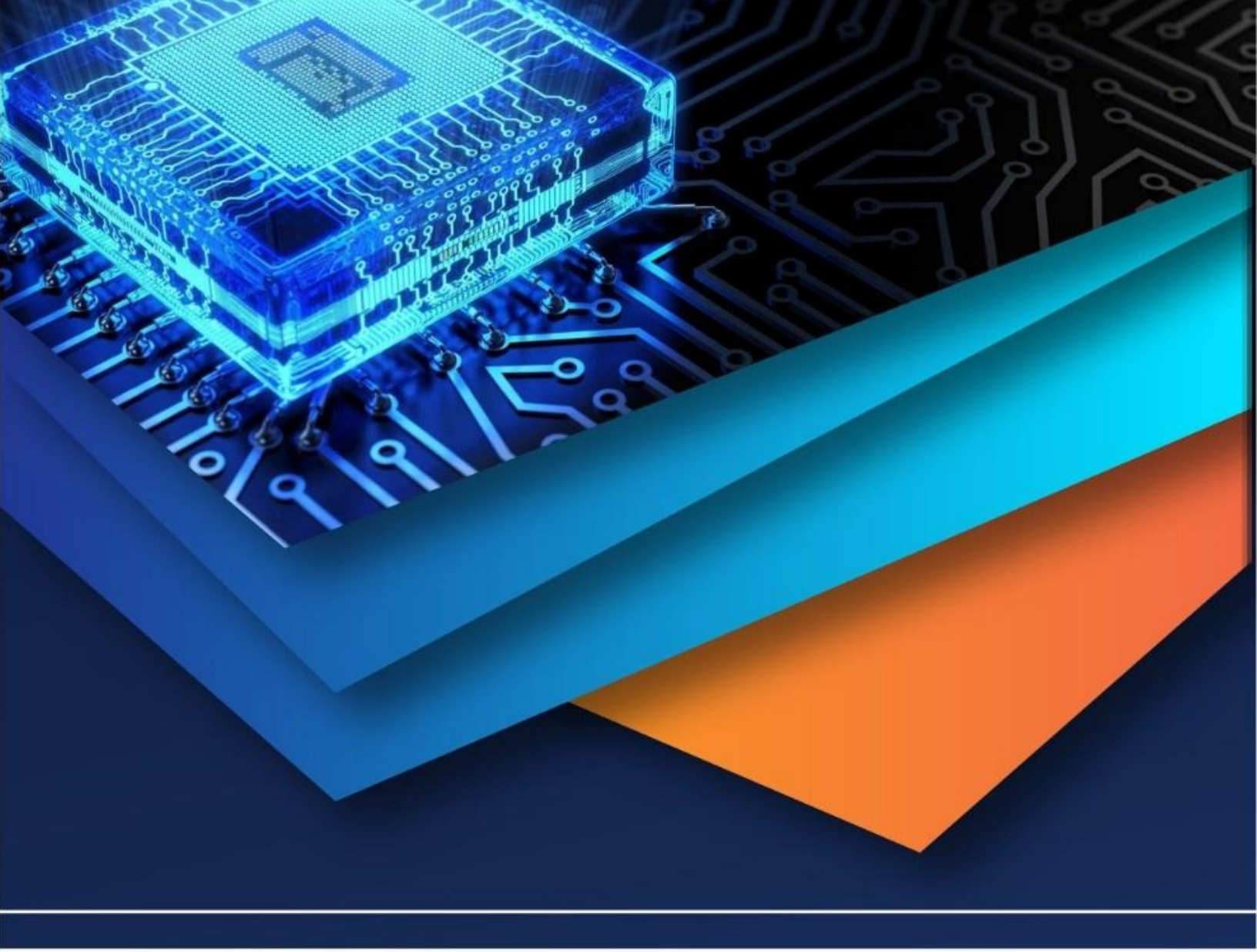

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