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Analysis of the Impact of Coal Mineacid Water on River Water Quality, Biota, and Human Health Around Mining

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ABSTRACT

Acid Mine Drainage (AMD) or Acidic Acidic Drainage (AAT) is a type of water runoff that happens when certain sulfide minerals in rocks come in contact with water and oxygen, triggering an oxidation process that results in water with acidic properties. To understand more about this phenomenon, a literature review was conducted using relevant keywords on online information sources. The indicators used to measure the level of acidity in mine water include pH, metal concentration, Total Suspended Solid (TSS) or turbidity level, electrical conductivity, sulfate, and sulfuric acid content. High electrical conductivity in mine water usually indicates the presence of metals such as iron (Fe) and manganese (Mn). High levels of manganese (Mn) in water can cause health problems for humans. Moreover, an increase in the concentration of Fe can cause an increase in turbidity or TSS because iron metal can dissolve in air and form solid particles that can cause turbidity. To reduce acidity and environmental pollution, passive or active treatment techniques can be used to neutralize AMD.

KeyWords: Environmental-impact, AMD, Coal, WaterQuality, Heavy Metals.

INTRODUCTION

Environmental pollution is a serious problem in many countries around the world. Various types of pollution contribute to this problem, and one of the biggest contributors is the mining industry. Coal mining, in particular, produces a by-product called AMD, which is a significant environmental pollutant (Maulida & Purwanti, 2023). Another environmental issue caused by mining operations is the formation of AMD, which continues to be a problem even after the mine is closed. AMD is a water runoff that is created when certain sulfide minerals in rocks are exposed to water and oxygen, leading to an oxidation process that produces acidic water. If the water is not properly rinsed, this chemical reaction can result in acid water being released from the source. Rainwater can also experience infiltration or percolation into rock piles, creating acid mine water (Fitrah, 2019). Liquid-containing sulfuric acid is created during the sulfide oxidation process, which also increases the concentration of metals such as iron, manganese, aluminum, cadmium, and others (Maulida & Purwanti, 2023).

The presence or absence of alkaline materials, as well as the type and quantity of sulfide minerals, influence both the acidity and the type of metal dissolved in AMD. Acid mine water, with a pH level below seven and sometimes even below three, can be neutralized by alkaline materials to reduce the amount of AMD produced. High acidity and dangerous concentrations of heavy metals are characteristics of AMD. When certain substances are introduced into a river, the aquatic ecosystem. This can lead to a decrease in the quality of the river water and even cause pollution that can poison fish and other aquatic organisms. As a result, the water may become unsuitable for consumption (Fitrah, 2019). AMD can negatively impact the health of people who rely on river water (Hidayat, 2017). The purpose of this journal is to explore the intricate consequences of AMD and to propose viable solutions to tackle the environmental and public health challenges that arise as a result of it.

METHODS

The literature review was conducted using an online search approach to gather articles on mining, coal, monitoring, water quality, and AMD from Google Scholar.

The search was conducted on scientific literature such as study papers and journal publications, and the article topics were limited to the last ten years (2013–2023). The search only included articles that did not solely contain concepts. A total of 408 results were found that focused on the quality of river water around coal mines. The search results are presented in Table 1, which includes the title, author, method, and results.

In the Google Scholar article search results, 408 publications were found using relevant keywords for this research. The researchers examined the title and abstract of each article, resulting in 73 obtained articles. Out of the 73 articles, 20 were found to be relevant to the research. After reading all 20 related articles, 8 were deemed eligible and acceptable. The process of selecting articles is illustrated in Fig 1, from identification to the selection of eligible articles. River water quality monitoring methods typically measure parameters such as acidity levels and the presence of heavy metals.

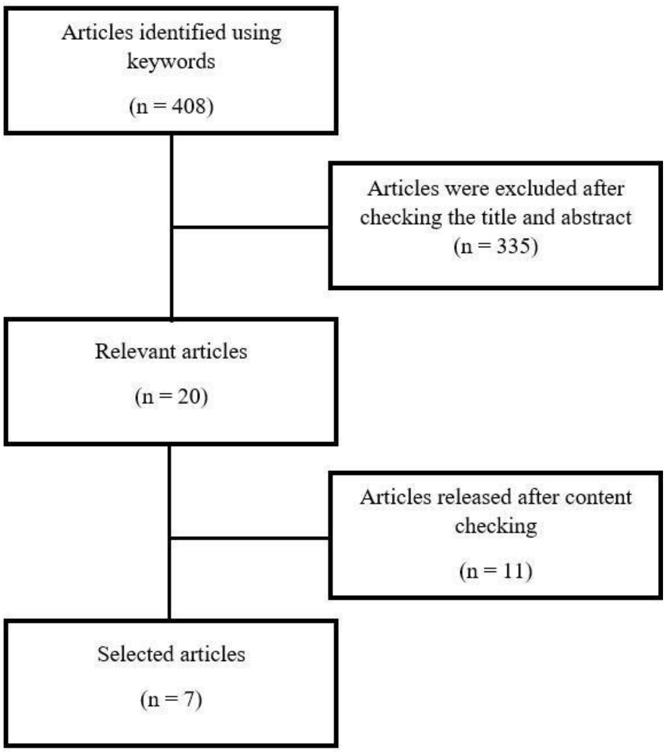

Fig 1. Article Selection

Table 1. Measurement result data

Title	Author/Year	Method	Results
Studi Pemantauan Air Limbah Cair Tambang pada PT. XXX di Muara Teweh Kalimantan Tengah	(Annisa et al., 2018)	In this research, the data collection technique used was a direct data collection technique, namely by taking water samples in the field at six predetermined places.	Environmental monitoring aims to regulate the quality of liquid mining waste before it is discharged into the aquatic environment. The parameter test results show that although some pH values are outside the acceptable range, the TSS values and metal content (Fe and Mn) meet the quality criteria. The fact that the excess pH is negligible indicates that PT. XXX is still under control.
Penaatan Perusahaan Tambang Batubara di Sawahlunto terhadap Peraturan Air Limbah Pertambangan	(Mukhlisah, 2020)	This research uses a direct data collection approach, namely collecting water samples at 11 pre-arranged locations and using mining wastewater analysis techniques that comply with ASTM and Indonesian national standards (SNI).	Research findings show that Sawah Lunto City coal mining wastewater does not meet the environmental quality criteria stipulated by Law Number 32 of 2009 of the Republic of Indonesia. There are maximum levels of suspended solids (TSS) and heavy metals iron (Fe) and manganese (Mn). As a result, river biota in the research area could be threatened and the environment could be damaged by the waste water.
Analisis Penanganan Air Asam Tambang Batubara	(Wahyudin et al., 2018)	Uses a combination of data types, such as field research, TSS data, pH data from settling ponds, and literature reviews, to conduct qualitative analysis and provide supporting information.	To maintain environmental and water quality, effective management of acid mine drainage is very important. Additionally, the effectiveness of the settling ponds was evaluated through the use of statistical analysis and AHP testing. This study also shows that management of acid mine drainage in coal mines can be successfully carried out using settling ponds.
Pengelolaan Air Asam Tambang (AAT) dari dinding bekas penambangan seibagai alternative penanggulangan pencemaran lingkungan: studi kasus tambang batu hijau, Nusa Tenggara Barat	(Suryadi, 2020)	The research method used in this paper to collect samples from the research location is known as sampling methodology. The population is determined as part of the process to ensure that the sample is representative of the study and to collect related data.	Knowledge and control of the environmental impacts of acid mine drainage are greatly enhanced by this research. To prevent environmental pollution and control acid mine drainage, successful management strategies are recommended. Planning and implementing AMD management is the aim of this research to prevent adverse impacts that could endanger the ecosystem.
Analisis pengaruh air asam tambang sekitar	(Kamarullah et al., 2022)	This research uses a number of research	The characteristics of acid mine water at UCW Disposal,

Disposal UCW di PT Jorong Barutama Greston		methods, including collecting field data, mapping the location of acid mine drainage, analyzing leachate water and river water quality in the laboratory, as well as preparing recommendations for acid mine drainage.	including low pH (2.5–3.7), low Fe metal concentration, high Mn metal concentration, and low turbidity level (TSS), are shown in the laboratory analysis results. If groundwater enters a river, the impact can be a decrease in water quality, which can be detrimental to people living in the river basin. If used for human water needs, acid mine drainage can have a negative impact on human health in addition to polluting the environment and disrupting water ecosystems. Therefore, to maintain the ecosystem and water quality, acid mine water must be treated.
Analisis Kualitas Air Dengan Penentuan Status Mutu Air Sungai Jaing Kabupaten Tabalong	(Yuniarti & Biyatmoko, 2019)	The research methodology includes analysis of the water quality of the Jaing River using the Pollution Index Method and the STORET Method to determine the water quality status.	Studies show that the water quality of the Jaing River. There is a change in water quality status from upstream to downstream because many water parameters exceed Class I quality norms. Water quality analysis takes into account biological, chemical and physical factors. The STORET Method and Contamination Index Method confirm the presence of coliform bacterial contamination from industry and surrounding communities, causing a decline in the quality of surrounding waterways and rivers.
Analisis Penetralan Air Asam Tambang dengan Metode Aktif Menggunakan Powerbase di Pit Timur PT Dizamatra Powerindo Kabupaten Lahat Provinsi Sumatera Selatan	(Rianti & Saputra, 2020)	Using a hybrid research method that combines experimental and descriptive methods. Experimental research is used to carry out experiments or laboratory tests, while descriptive research explains and describes data obtained in the field.	The aim of this research is to reduce the negative impact of acid mine drainage (AMD) on the environment by neutralizing it before it enters the river. Calculating water outflow, Powerbase dosage, and Powerbase dosage costs at laboratory and field scales was also part of the research. Due to regular monitoring and neutralization of water discharged into rivers, the mine has less direct impact on surrounding communities.

RESULTS

The AMD can harm ecosystems. Mining operations have many negative impacts, including the negative effect on the quality of river water. The indicators for measuring acid mine water comprise pH, metal concentration, turbidity level or Total Suspended Solid (TSS), electrical conductivity, and sulfate and sulfuric acid content (Kamarullah et al., 2022). Sulfide minerals like pyrite oxidize to create sulfuric acid, which then reacts with rocks and minerals to release sulfates into the water, causing acid mine drainage (Hidayati, 2021). AMD is created by sulfide minerals, including FeS2, CuS2, CuS, CuFeS2, MoS2, NiS, PbS, and ZnS. Pyrite, commonly found in coal mining, is the most frequently occurring sulfide mineral in mining operations. The high concentration of sulfate in acid mine water can cause a decrease in pH, resulting in increased acidity (Wahyudin et al., 2018). The pH value of AMD has been measured in several relevant studies and found to be less than 7, indicating a high level of acidity. This can greatly damage the aquatic environment and affect water quality, potentially endangering the lives of aquatic species. It can also disrupt the food chain and hurt human health (Yuniarti & Biyatmoko, 2019). The main impact of acid mine water on the environment is its low pH level. This high acidity level also harms the digestive and respiratory systems of aquatic creatures, including fish.

Electrical conductivity in deep acid mine drainage (Kamarullah et al., 2022) based on the results of laboratory analysis, shows high values, which can be an indication of the presence of metals in water such as Fe and Mn. Low pH values can also increase the concentration of dissolved heavy metals in water, (Kamarullah et al., 2022) There are measurements of high concentrations of Mn in AMD which can hurt the environment and human health if there is a possibility of using channel water to meet water needs. High concentrations of Mn in water affect human health in the form of chronic exposure to manganese which can cause damage to the central nervous system, which can result in impaired cognitive function, behavioral changes, and motor disorders. Additionally, long-term exposure to manganese has also been linked to an increased risk of Parkinson's disease (Rianti & Saputra, 2020).

The high concentration of Fe in acid mine water is also increased by the low pH, causing the water color to change to yellow-brown. An increase in the concentration of Fe can contribute to increased turbidity or TSS because iron metal can dissolve in the air and form solid particles that can cause turbidity (Rianti & Saputra, 2020). High TSS can cause a decrease in water quality, inhibit the penetration of sunlight into the water, and disturb aquatic life. Solid particles in TSS can also be a medium for transporting heavy metals and other toxic compounds, which can increase water pollution and damage aquatic ecosystems. Research (Suryadi, 2020) shows how aquatic life, including fish and aquatic insects, react negatively to water contaminated by AMD, this negative impact is in the form of a decrease in the diversity and abundance of animals in rivers.

The AMD can be neutralized using passive or active treatment techniques. Acid mine drainage aims to reduce acidity and environmental pollution. Acid mine drainage is a prerequisite for an active processing system, which uses chemical processing to continuously neutralize the acid. Dissolved metals will settle during this neutralization process, creating a mud blanket. The disadvantage of this approach is that removing or disposing of mud flaps that contain metal is expensive. Passive techniques offer advantages in AMD processing, especially in reducing costs and maintenance. Passive processing systems only need to be replaced and maintained regularly (Rianti & Saputra, 2020). According to research (Suryadi, 2020) Active management involves mixing acidic mine drainage with alkaline substances, such as lime, which is alkaline (basic) to neutralize the acid. Passive management involves managing something naturally without human intervention, but the infrastructure is created by humans. These two methods are important proactive steps to maintain environmental balance and an effort to take moral responsibility for the impact of mining exploitation on nature and the ecosystem. Management of acid mine drainage also has its challenges, such as those (Kamarullah et al., 2022) The main challenges in addressing the impacts of AMD are complying with environmental standards, treating mine water to a quality that allows for reuse in the environment, and protecting human health where canal water can be reused.

CONCLUSIONS

The AMD is produced from coal mining activities and has the potential to disrupt ecosystems, especially river water quality, river biota, and human health. Management of AMD through passive or active treatment procedures is necessary because it has negative impacts, including changes in pH, metal concentration, TSS, electrical conductivity, and sulfate and sulfuric acid content. Active treatment solutions require acid mine drainage, but passive methods have advantages in terms of cost and maintenance. Complying with environmental regulations, restoring mine water to levels suitable for reuse, and safeguarding public health in connection with the reuse of canal water are key challenges in mitigating the impacts of AMD.

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