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Coupling the Creation of Biogenic Nanoparticles with Metal Recovery through Biometallurgy

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Abstract

Metal contamination in the environment can be caused by industrial processes such mining, electroplating, cement manufacture, metallurgical operations, as well as the production of plastics, fertilisers, insecticides, batteries, dyes, and anticorrosive agents [1-15]. Due to the non-biodegradable nature of metal pollution, their conversion into hazardous and cancer-causing chemicals, and their bioaccumulation along the food chain, this is an urgent issue. The recovery of rare earth elements and platinum group metals is encouraged at the same time due to their high commercial importance. Metal recovery in the form of nanoparticles can be facilitated by microbial interaction with metals or metal-bearing materials. Because of their distinct properties and potential uses, metal nanoparticles are receiving more and more attention. agents that fight bacteria and biofilms, biocatalysts for wastewater treatment, targeted medicine delivery, and water electrolysis. Metal nanoparticles ought to be uniform in size and shape and safe for both people and the environment. In contrast to chemical and physical processes, microbial production of nanoparticles is a safe and sustainable method. In this review paper, we primarily focus on the benefits of using metal and metal salt nanoparticles produced by a variety of microorganisms, including bacteria, fungus, microalgae, and yeasts, in biological, health, and environmental applications.

Metals and non-metals are supplied to the manufacturing and refining industries by mining, mineral processing, and extractive metallurgy. Mining produces waste products, just like all industrial activities do, and these wastes need to be properly treated and disposed of in order to prevent environmental damage. Additionally, the creation of cement, the burning of fossil fuels, the tanning of leather, and the production of plastics, fertilisers, Ni-Cd batteries, paints, pigments, and dyes result in the formation of wastewaters that are high in metal ions. Due to the non-degradable nature of some metal compounds, their potential toxicity or carcinogenicity, as well as their accumulation in animals through the food chains, metal-rich wastewaters pose a severe hazard to the ecosystem. The United States Environmental Protection Agency works to reduce contamination.

Introduction

According to the US Environmental Protection Agency (1976-2015), 2014, the agency has strict regulations on the discharge of priority pollutant metals into the environment. Two kinds of materials have been proposed by the European Commission (Directive 80/68/EEC), some of which are prohibited from discharge into ground water and others of which are permitted to discharge but call for prior authorization. The first list contains substances that are completely prohibited from being discharged directly, such as organohalogen, organophosphorus, and organotin compounds, mercury, cadmium, and their compounds, and hydrocarbons like cyanides. The second list includes biocides, fluorides, poisonous or persistent organic silicon compounds, some metals like copper, zinc, lead, and arsenic, as well as other chemicals and its derivatives, which can be discharged but need prior approval, but are not on List I. Although zinc and copper are necessary trace metals for humans, excessive amounts can cause nausea, vomiting, and skin irritation. There Because they can cause serious harm to the lungs and kidneys, are carcinogenic, and are neurotoxic, nickel, lead, and mercury are particularly hazardous Because they are used in electrical certain metals are valuable raw materials for biomedical devices, catalytic processes, low-carbon technology, etc (Vidal et al., 2013). Critical and rare metals with high economic importance include the platinum group metals, rare earth elements, cobalt, selenium, and tellurium. According to Table 1 from the European Commission's Enterprise and Industry report from 2014, there are a total of 14 raw materials with a high supply risk and significant economic relevance for the European Union. For the mentioned raw metals to be used as a whole in low carbon energy technologies (nuclear, solar, wind, and bioenergy), certain elements, such as indium When AMD is produced, appropriate remediation methods are employed to reduce its detrimental effects on recipient water bodies and ecosystems. These methods might be passive. Because remediation methods have limitations, preventing AMD formation can lessen its negative effects on the environment. Excluding any of these elements would naturally prevent AMD from developing because AMD is created by the oxidation of sulphide minerals in the presence of oxygen, water, and microorganisms.

Subjective Heading

AMD is a serious environmental problem for the mining and mineral processing industries due to its unusually low pH (3.0) and high concentrations of potentially dangerous dissolved metals, metalloids, and sulphate. If AMD is not effectively managed, it causes considerable environmental degradation, soil and water contamination, serious

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health issues for nearby communities, and the loss of biodiversity in aquatic .

In relation to biotechnological procedures for the extraction of metals from ores and concentrates as well as bioremediation of pollutants, microbial interactions with metals have been widely researched By utilising metals from the soil, many microorganisms, including bacteria, fungus, algae, and yeasts, can biosynthesize nanoparticles through a process known as biomineralization. Living organisms have been shown to create minerals without any obvious regulatory pathways for a long time .The minerals produced using this passive method are chemically comparable to those created using inorganic processes.

Discussion

Additionally, as an eco-friendly and non-toxic alternative to physical and chemical approaches, this natural method of creating nanoparticles by microorganisms has a number of advantages. There are two popular physical and chemical methods for creating nanoparticles: top-down and bottom-up. Using physical and chemical techniques, bulk materials are reduced to smaller particles in the top-down process. Atoms self-assemble in the nucleus that produce nanoparticles using the bottom-up method .Since researchers have been looking into large-scale synthesis of various metal nanoscale structures, microbial fermentation reflects a state-of-the-art technology for large-scale processing of such structuresnanoparticles that follow biogenic pathways.In 2010, bacterial fermentation was used for the first time on a large scale to produce magnetic nanoparticles at a very low cost, yielding more than 1 kilogramme of Zn-substituted magnetite ($Zn_{0.6}Fe_{2.4}O_4$) from a 30 L bacterial fermentation Thermoanaerobacter sp., a metal-reducing bacteria, was used to produce cadmium sulphide (CdS) nanostructured particles at a high scale (10 nm size) with proven reproducibility of 3 g/L of growing medium/month and scalability up to 24 L in this continuation by A thermophilic organism is Thermoanaerobacter sp. anaerobic bacteria that reduces metal. In laboratory-scale (24 L) reactors, Thermoanaerobacter sp. X513 efficiently produces zinc sulphide (ZnS) nanoparticles (NPs). Moon et al. (2016) decided to use 100 L and 900 L reactors to transition the production of nanoparticles from lab size to pilot scale as a result. The 900 L pilot plant reactor produced about 320 g ZnS without any process optimization or replacement of the used medium; this quantity will be sufficient to build a ZnS thin film with a thickness of about 120 nm over 0.5 m width and 13 km in length (Moon et al., 2016). For industrial use, full-scale biotechnological techniques have been developed for metal-containing wastewater treatment and biomining, which extract base metals from ores. The review is based on studies and reviews that were found using the PubMed search tools by using the terms "Biometallurgical recovery of metals," "Microbial synthesis of nanoparticles," and "Metal nanoparticles" in the search menu over the previous From 2010 to 2020, the keyword "biometallurgical recovery of metals" yielded just 6 publications, whereas the phrase "microbial synthesis of nanoparticles" yielded 3156 articles in 2010 and 7301 articles in 2018.

Sustainable resource usage is one of the biggest problems facing the current world economy. The mining sector uses a lot of water and is under increasing scrutiny for how it disposes of that water and how it affects the environment. Authorities, investors, and stakeholders are putting pressure on businesses to reveal their water usage and disposal statistics and to adhere to ever-stricter restrictions .Particularly in water-scarce places, strategic water management has become crucial for robust business operations and long-term profitability. Mining operations are impacted by AMD formation because corporations must adhere to environmental regulations. Failure to treat water could have negative effects, including financial losses, the revocation of operating licences, interruptions in production, and societal unrest.

Despite the fact that the mechanisms causing AMD formation are very well understood, little research is being done on ways to prevent AMD .Rarely are full-scale preventive measures used; instead, AMD development is typically mitigated but not totally prevented. As a result, the majority of research has concentrated on reducing the effects of AMD, and creating novel AMD treatment strategies is highly sought after. A wide variety of techniques have been looked into. An summary of study findings on AMD treatment in lab and pilot size was presented by Gaikwad and Gupta. The report displayed a large Despite the fact that the mechanisms causing AMD formation are very well understood, little research is being done on ways to prevent AMD Rarely are full-scale preventive measures used; instead, AMD development is typically mitigated but not totally prevented. As a result, the majority of research has concentrated on reducing the effects of AMD, and creating novel AMD treatment strategies is highly sought after. A wide variety of techniques have been looked into. An summary of study findings on AMD treatment in lab and pilot size was presented by Gaikwad and Gupta.The report displayed a large.

It's crucial to remember that for successful AMD therapy, a number of different procedures are frequently needed. Despite technological advancements, neutralising acidic streams with an alkali chemical (such as limestone, slacked lime, or caustic soda) is still the most popular way for AMD repair The procedure needs little equipment, employs cheap chemicals, is temperature-insensitive, and could be quickly modified to accommodate changes in flow and pH. The disadvantage is the large-scale generation of iron sludge that is combined with other metal hydroxides and gypsum. The sludge must then be treated to stop metals from dissolving again. Furthermore, neutralisation frequently fails to fulfil updated environmental regulations for dissolved metals because of the high solubility of metal hydroxides.

For total dissolved solids, certain nations have set restrictions. Additionally, some have already established sulphate content limits for surface and groundwater that range from 250 to 1000 mg/l. Gypsum precipitation alone can only produce sulphate concentrations of about 1200 mg/l, hence it fails to meet requirements for lower limits. Consequently, mining firms are compelled to invest in more sophisticated water treatment systems Due to these factors, the public and business sectors are starting to show an interest in compiling best practises and creating guidelines for AMD repair. The US EPA guideline from 2014 specifies 16 of these, just to name a few mentions mine locations that employ remediation technology .The Global Acid Rock Drainage Guide (GARD Guide), which was published by the International Network for Acid Prevention (INAP) in 2014, includes a thorough overview of AMD mitigation options as well as a detailed analysis of the chemistry underlying AMD development. United States Environmental Protection Agency. In 2017, the Nordic Council of Ministers published the findings of a study that attempted to compile best practises employed in the region and build a concept of water mindful mining. These rules make it easier for local communities, academic institutions, government agencies, and mining firms to work together. Furthermore, they Point out the drawbacks of the current methods and tendencies for the development of the future. Resource recovery from AMD is a new strategy that has been covered in various articles recently (Buzzi Electrodialysis for water recovery has been proposed .but they have encountered membrane clogging that has decreased the process' efficiency. According to AMD in South Africa may be amenable to acid recovery by freeze crystallisation and acid retardation techniques. States in Africa and Sub-Saharan Africa are now manufacturing sulfuric acid from sulphur or by smelting pyrite .The authors emphasised the drawbacks of these processes, namely their high energy requirements and lack of purity in the end products. cited various papers that concentrated on recovering iron oxides from AMD, for example for the manufacturing of pigments. The proposed approaches must be further developed, and issues like process design, product quality, and energy utilisation must be taken into consideration, according to all of the writers. The water itself, for reuse and recirculation, and the solutes dissolved in the drainage, which include sulfuric acids, are the two most valuable commodities that may be collected from AMD. Reverse osmosis and nano-filtration are the primary methods used to recover and treat water from AMD Another place provides a thorough analysis of different membrane techniques for recovering water from AMD To cut down on the use of freshwater, treated water can be recycled back into the mine processing facilities. Water recycling should be done with caution, though, as it could lead to unstable water quality, which could impair plant performance, particularly in flotation circuits Another potential valuable resource that can be recovered from AMD is sulfuric acid, which can be used for chemical reagents and has been shown to be of sufficient quality to meet.

Conclusion

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Conflict of Interest

The authors declare that they are no conflict of interest.

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