



Treatment of Gold Mine Wastewater to Remove Heavy Metals with Emphasis on Cyanide Using Natural Adsorbents

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Article Info	ABSTRACT
Article type: Research Article	In gold mines, large amounts of wastewater are produced annually due to the processing processes of the mine. These wastewaters contain large amounts of heavy metals and cyanide. due to the pollution of heavy metals and cyanide as well as the dangers of these pollutants to human health and the environment, it is necessary to develop and test the correct and economic solution for management of this type of wastewater. In this research, a gold mine in Iran as a sample mine to collect drainage water for quantitative and qualitative analysis in order to determine the amount of heavy metals and cyanide is considered. In the analysis of this drainage, it was found that heavy metals such as lead, manganese, arsenic, zinc and iron and cyanide are in higher levels. In order to evaluate the efficiency of adsorption method in the treatment of gold mine wastewater, a laboratory pilot was designed and then organic adsorbents including leaf soil and mushroom compost as well as inorganic adsorbents including lime and zeolite were selected according to different criteria. In the pilot study, one layer of each adsorbent was placed and the drainage sample was poured into the pilot. The results showed that the adsorbents had good performance in the period of time and recorded high removal of 95 % which indicates the effect of selected adsorbent in the treatment of gold mine wastewater.
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INTRODUCTION

Gold is regarded as one of the most precious minerals, with mining activities commencing thousands of years ago when gold was extracted from ore. Its high value is attributed to its resistance to most volatile substances, with cyanide being a notable exception. Environmental concerns have been associated with mining operations since their inception (Eddinger, 2012). The industrial production of gold generates a significant amount of waste, which adversely impacts the environment. One of the primary waste streams from gold processing facilities is mine waste. Several factors influence the physicochemical composition of this waste, including the type of ore, the reagents employed, the processing methods utilized, and the size of the milled material. Typically, waste may contain heavy metals, cyanide, metalloids, radioactive metals, and sulfide minerals (Thygesen et al, 2017). The principal source of cyanide ions

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entering the environment is sewage. Due to the difficulty in the uptake or storage of cyanides in soil, they are predominantly found in the aqueous phase and often form complexes with other materials (Jaszczak et al, 2017). Cyanide compounds are utilized across numerous sectors, such as chemical, pharmaceutical, food, and mining industries, consequently wastewater generated from these sectors is often contaminated with cyanide compounds (Freitas & Horta, 2023). In light of the toxicity concerns surrounding cyanide, particularly in gold mining, the presence of cyanide has emerged as a significant issue. Although alternatives to cyanide are being explored, its strong capacity to form stable complexes with gold ensures its continued use (Alvillo-Reiveira et al, 2021). Most individuals exposed to high concentrations of cyanide typically recover within minutes. Exposure through inhalation, ingestion, or skin contact can lead to cyanide toxicity (Nelson, 2006). Cyanide ions inhibit cellular oxygen uptake, resulting in hypoxia and the accumulation of lactic acid within cells. This occurs when cyanide binds with cytochrome c, obstructing enzyme reactions. As a result, cellular respiration is hindered (Cleven et al, 2000). the estimated lethal dose (LD50) is 1 mg/kg, whereas 50% of the injected liquid is approximately 100 mg / kg (Baskin et al, 2008). Contact with a solution containing CN can cause skin irritation and wound (Cope, 2020). according to histopathological examination, liver and brain tissues are affected by sodium cyanide concentration between 1 and 50 mg/L (Eddinger, 2012). Consequently, advancing research in wastewater treatment that is both effective and applicable is crucial for achieving a responsible mining scenario.

Various strategies for treating wastewater containing cyanide have been extensively researched over the years, such as degradation through chemical processes, biological filtration, activated carbon and resins, alkaline chlorination, oxidation using hydrogen peroxide, the INCO process, ozonation, incineration, complexation and precipitation, and photodegradation, among others. Methods for purifying heavy metals encompass membrane filtration, chemical purification techniques that utilize coagulation and flocculation, as well as absorption methods primarily reliant on individual adsorbents or electrocoagulation. While membrane filtration demonstrates effective performance, challenges such as membrane fouling and recovery present significant issues. Coagulation and flocculation methods are cost-effective; however, they generate a considerable amount of sludge. Similarly, adsorbent-based purification methods are both economical and effective, yet their recovery poses potential difficulties (Nthwane et al, 2025). In cyanide purification techniques, the hydrogen peroxide-based approach has demonstrated commendable performance; however, it incurs substantial operating costs. The Inco method has also shown notable efficiency, yet it necessitates side solutions and may elevate sulfate concentrations. The alkaline chlorination method, recognized as one of the traditional and effective techniques, generates a significant number of toxic byproducts. Furthermore, recent advancements in biological methods have yielded satisfactory efficiency, but they require meticulous control of the microbial environment (Freitas & Horta, 2023). When choosing a treatment method, it is crucial to consider both the costs associated with treatment and the environmental impacts of the resulting products, as many methods can produce new toxic substances (Freitas & Horta, 2023).

Various studies have been conducted using various adsorbents to investigate the effectiveness of cyanide removal from gold mining wastewater, but few studies have combined organic and inorganic adsorbents. For example, in a study in 2025, a specific type of activated carbon was used to purify iron and manganese from acidic mineral wastewater, with removal efficiencies ranging from 55 to 99 percent under various conditions (Paradise & Patama, 2025). Or in another study, a specific biochar from coconut husk was used to remove toxic metals from mineral wastewater, with a removal range of 50 to 98 percent achieved under laboratory conditions (Duwiewuah et al, 2025).

Based on the points discussed above, the objective of this research is to evaluate the efficiency of removing heavy metals—specifically cyanide—from gold mine wastewater and to propose effective, low-cost adsorbents for this purpose.

MATERIALS AND METHODES

The chosen approach involves the use of both natural and synthetic adsorbents for the treatment of wastewater generated by gold mining operations. To implement this, a sewage sample was collected from a gold mine within the country. The necessary parameters for the wastewater sample are outlined as follows: subsequent analysis revealed that the concentrations of heavy metals and cyanide exceeded the permissible limits, necessitating effective treatment to reduce their levels to within standard thresholds. In Table 1, you can see the analyzed values of the input to the pilot.

To determine the pilot dimension of the software, the wastewater treatment model for mines, known as AMDtreat, is utilized. This model is computed and implemented by adjusting the height, length, width, and duration of the necessary dimensions. The computer program for modeling wastewater treatment was introduced in 2003 by the U.S. Department of Surface Mining and Reclamation. It has been extensively adopted by authorities in mining, industry, and watershed management across the United States and other nations to estimate wastewater treatment costs.

In order to design the pilot, the volume and dimensions are first calculated based on different retention times (6-30 h). In this case, the depth of the organic and inorganic material layers is assumed to be constant. As expected, increasing the retention time causes an increase in dimensions, but in contrast, when the retention time is constant, the dimensions of the pilot become smaller with increasing the depth of the inorganic absorbent materials, which is also due to the increase in the rate of alkalization of the environment due to the increase in the number of neutralizing materials. According to the results obtained from the sensitivity analysis of the effect of retention time and inorganic materials on the dimensions of the desired pilot, it was observed that the average length, width, and height were calculated as $2.4 \times 65.6 \times 118.9$ meters, respectively. In order to determine the dimensions, the desired values can be considered as $3 \times 60 \times 120$ m with a volume equal to 21600 m^3 . For a more efficient implementation of vertical flows and the effect of removing heavy metals and reducing the existing cyanide, an attempt was made to consider the obtained volume as a vertical cubic cylinder in order to best examine the process of changes. For this reason, the dimensions of the pilot were considered as $30 \times 30 \times 60$ cm. As for the retention time, the default time range was between 6 and 30 hours,

Table 1. Analysis of required input parameters

No	Analysis Name	Method	Value	Unit
1	Na	Atomic Absorption	141	mg/L
2	Fe	Atomic Absorption	250	mg/L
3	Zn	Atomic Absorption	60	mg/L
4	As	Atomic Absorption	34	mg/L
5	Pb	Atomic Absorption	170	mg/L
6	Mn	Atomic Absorption	86	mg/L
7	CN	Atomic Absorption	12	mg/L

which includes 12 to 24 hours. In Table 2, you can see the values obtained for the desired pilot dimensions from the software.

In this pilot study, a variety of adsorbents, encompassing organic, inorganic, and hybrid types, were employed to eliminate heavy metals and other contaminants from mine wastewater. The hydraulic retention time (HRT) of these systems is a significant factor, and this research utilizes software modeling to optimize mining processes. This optimization aligns with existing resources, previous studies, and our expectations for pollutant removal, thereby determining the optimal quantities required. Furthermore, the design of the pilot's dimensions, including its volume, is a critical consideration. By evaluating different retention times for this volume, the ideal volume of adsorbents is calculated. In this scenario, while maintaining a constant layer depth, the depth is variable, and the retention time remains fixed, allowing for the optimization of layer depth and ultimately achieving the desired volume and dimensions.

Based on the previous studies and also examining the management and economic considerations and easy navigation of the following adsorbents for use in the pilot system. Table 3 shows the adsorbents used, along with the amount required and their type.

In Table 5, you can see the composition of the adsorbents used, along with their height and the amount of wastewater solution used.

In Fig 1 images of the pilot are shown in different cases.

Considering the desired input and output values, the removal efficiency of each of the heavy metals in question, especially cyanide, has been calculated through the following equation (1) (Zenasni et al,2012): Adsorption percentage (%) was derived from the difference of the initial concentration (C_0 , mg/L) and the final one (C_e , mg/L).

$$\text{Sorption}\% = \frac{C_0 - C_e}{C_0} \times 100\% \quad (1)$$

Table 2. Output dimensions from the software

Layers	Length	Width	Height	Length to width ratio
Minimum dimensions	79.1	45.7	2.4	1.7
Maximum dimensions	150.2	81.2	2.4	1.9
Average dimensions	118.9	65.6	2.4	1.8

Table 3. Adsorbents used and their quantities

Adsorbent	Amount	Type
Compost	1 bag of 25 kg	Organic
Zeolite	1 pocket of 25 kg	Inorganic
Lime	Cobblestone 3 kg	Inorganic
Leaf	1 bag of 2 kg	Organic

Table 4. Specifications of the zeolite used

Adsorbent	Specific gravity(g/cm ³)	Water absorption	Particle size distribution(mm)	Color	Ion exchange capacity(meq/gr)
Zeolite	0.5-1.1	60% by volume	1-3	White	3.6

Table 5. Combination of adsorbents in the pilot, along with their heights and the volume of the wastewater

Layers	Height of layers	Volume of solution
Zeolite + Leaf Soil	10 cm + 10 cm	6 liters
Lime + Leaf Soil	10 cm + 10 cm	6 liters
Lime + Compost	10 cm + 10 cm	6 liters
Zeolite + Compost	10 cm + 10 cm	6 liters

**Figure 1.** Sample of adsorbents layers

For statistical calculations of data obtained from experiments in different situations, the following parameters, including Standard deviation(Equation(2&3)) and Mean(Equation(4)), along with their calculation formulas, were used. The standard deviation (SD) and the estimated standard error of the mean (SEM) serve to illustrate the characteristics of sample data and elucidate the outcomes of statistical analyses. SD reflects the variability of data within a normal distribution, essentially indicating the degree to which the mean accurately represents the sample data. Conversely, SEM encompasses statistical inference derived from the sampling distribution, representing the SD of the theoretical distribution of sample means (the sampling distribution) (Lee et al,2015).

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2} \quad (2)$$

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2} \quad (3)$$

$$\text{Mean}(x_i) = \frac{\sum_{i=1}^n X_i}{n} \quad (4)$$

Where n sample size, X_i elements in sample and $\bar{X}$ sample mean.

RESULTS AND DISCUSSION

The different results obtained from the output sample of each of the different pilot conditions, in proportion to the desired retention time, as well as the analysis of the output sample from the pilot after the purification process, can be seen in the Tables 6-9.

Table 6. Pilot output results in the first case (Zeolite/Leaf soil)

No.	Analyze Name	Analyze Methode	Value	Unit
1	Na	Spectrometer	112	mg/L
2	Fe	Spectrometer	0.06	mg/L
3	Zn	Spectrometer	0.01	mg/L
4	As	Spectrometer	< 0.005	mg/L
5	Pb	Spectrometer	< 0.02	mg/L
6	Mn	Spectrometer	< 0.01	mg/L
7	Cyanide	Photometry	< 0.002	mg/L

Table 7. Pilot output results in the second case (Lime/Leaf soil)

No.	Analyze Name	Analyze Methode	Value	Unit
1	Na	Spectrometer	130	mg/L
2	Fe	Spectrometer	0.07	mg/L
3	Zn	Spectrometer	< 0.005	mg/L
4	As	Spectrometer	< 0.005	mg/L
5	Pb	Spectrometer	< 0.2	mg/L
6	Mn	Spectrometer	< 0.01	mg/L
7	Cyanide	Photometry	< 0.002	mg/L

Table 8. Pilot output results in the third case (Lime/Compost)

No.	Analyze name	Analyze Methode	Value	Unit
1	Na	Spectrometer	117	mg/L
2	Fe	Spectrometer	0.06	mg/L
3	Zn	Spectrometer	< 0.005	mg/L
4	As	Spectrometer	< 0.005	mg/L
5	Pb	Spectrometer	< 0.02	mg/L
6	Mn	Spectrometer	< 0.01	mg/L
7	Cyanide	Photometry	< 0.002	mg/L

Table 9. Pilot output results in the fourth case (Zeolite/Compost)

No.	Analyze name	Analyze Methode	Value	Unit
1	Na	Spectrometer	88	mg/L
2	Fe	Spectrometer	0.05	mg/L
3	Zn	Spectrometer	0.025	mg/L
4	As	Spectrometer	< 0.005	mg/L
5	Pb	Spectrometer	< 0.02	mg/L
6	Mn	Spectrometer	< 0.01	mg/L
7	Cyanide	Photometry	< 0.002	mg/L

According to the obtained values from different and obtainable parameters in the Tables 6-9 we can conclude that in all of the cases, we experienced a desirable amount of heavy metal removal and the cyanide; and only in some of the other parameters, there is a difference in the removal rate of heavy metals and in general it can be stated that selective adsorbents were suitable and desirable performance in treatment of heavy metals and cyanide as mentioned earlier; in order to investigate the effect of removal of heavy metals and cyanide from gold mine wastewater, inorganic and inorganic adsorbents were used simultaneously in the pilot study. In the tables and graphs, the efficiency of this method was studied in different situations. In this section, values are considered in order to better design the graphs. Finally, the comparison graphs show that the parameters in different states are removed. In this section, values are assumed as constant numerically in order to make the graphs better. Below are Tables 10-13 showing the efficiency of each mode in removing each of the parameters in question. You can also see comparative charts (Figs 2 and 3) of the amount of parameter removal in different cases.

As illustrated in Figure 2, and taking into account Table 1, which presents the input values for the pilot, along with Tables 12 and 13 that detail the output values of the parameters in the compost-zeolite and compost-lime conditions, it can be inferred that a high level of efficiency has been attained in both scenarios, albeit with minor variations. In the aforementioned figure, the cyanide removal rate is recorded at 11.98 mg/L, while the other parameters include manganese at 85.99, lead at 169.98, arsenic at 33.995, zinc showing a slight difference in both instances at 59.99, and iron at 249.94 removal units. As illustrated in Figure 2, and taking into account Table 1, which presents the input values for the pilot, along with Tables 10 and 11 that detail the output values of the parameters in the leaf soil-zeolite and leaf soil-lime conditions, it can be inferred that a high level of efficiency has been attained in both scenarios, albeit with a minor discrepancy. The aforementioned figure indicates a cyanide removal rate of 11.98 mg/L, while the other

Table 10. Efficiency in the first case (Zeolite/Leaf)

No	Analyze	Input(mg/L)	Output(mg/L)	Removal Efficiency (%)
1	Na	141	112	20/56
2	Fe	250	0.06	99/9
3	Zn	60	0.01	99/98
4	As	34	< 0.005	99/97
5	Pb	170	< 0.02	99/98
6	Mn	86	< 0.01	99/98
7	Cn	12	< 0.002	99/98

Table 11. Efficiency in the second case (Lime/Leaf)

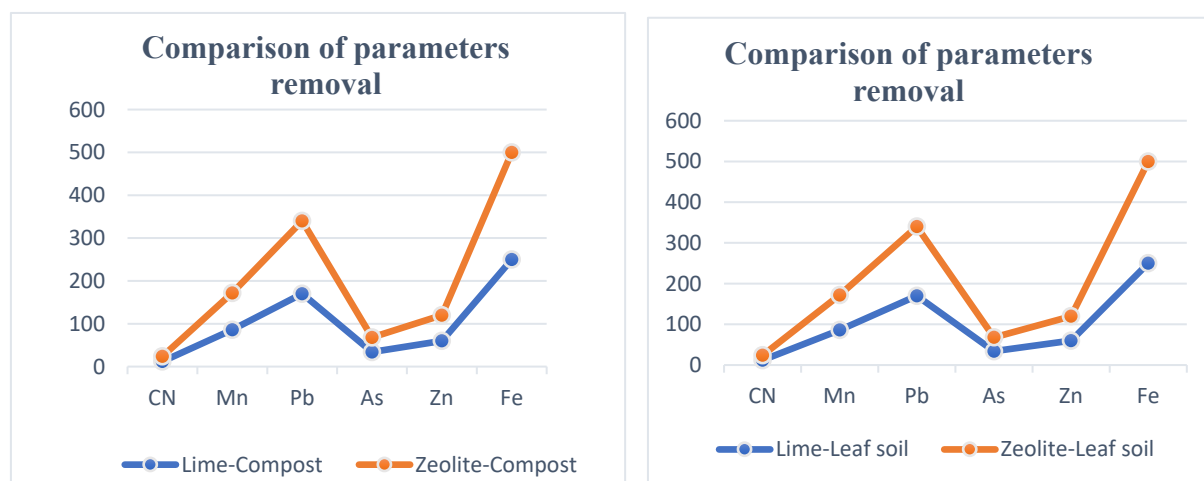
No	Analyze	Input(mg/L)	Output(mg/L)	Removal Efficiency(%)
1	Na	141	130	7/80
2	Fe	250	0.07	99/97
3	Zn	60	< 0.005	99/99
4	As	34	< 0.005	99/98
5	Pb	170	< 0.2	99/88
6	Mn	86	< 0.01	99/98
7	Cn	12	< 0.002	99/98

Table 12. Efficiency in the third case (Lime/Compost)

No	Analyze	Input(mg/L)	Output(mg/L)	Removal Efficiency(%)
1	Na	141	117	17/02
2	Fe	250	0.06	99/9
3	Zn	60	< 0.005	99/99
4	As	34	< 0.005	99/98
5	Pb	170	< 0.02	99/98
6	Mn	86	< 0.01	99/98
7	Cn	12	< 0.002	99/98

Table 13. Efficiency in the third case (Zeolite/Compost)

No	Analyze	Input(mg/L)	Output(mg/L)	Removal Efficiency(%)
1	Na	141	88	37/58
2	Fe	250	0.05	99/98
3	Zn	60	< 0.025	99/95
4	As	34	< 0.005	99/98
5	Pb	170	< 0.02	99/98
6	Mn	86	< 0.01	99/98
7	Cn	12	< 0.002	99/98

**Figure 2.** Graph comparison of parameters in fixed organic layer

parameters exhibit manganese at 85.99, lead at 169.98, arsenic at 33.995, zinc showing a slight variation in both instances at 59.99, and iron at 249.93 removal units. As illustrated in Figure 3, and in conjunction with Table 1, which presents the input values for the pilot, as well as Tables 11 and 12, which detail the output values of the parameters in the leaf soil-lime and lime-compost conditions, it can be inferred that a high level of efficiency has been attained in both scenarios, albeit with a minor discrepancy. The aforementioned figure indicates that the cyanide removal rate stands at 11.98 mg/L, while the other parameters exhibit manganese at 85.99, lead at 169.98, arsenic at 33.995, zinc showing a slight variation in both instances at 59.99, and iron

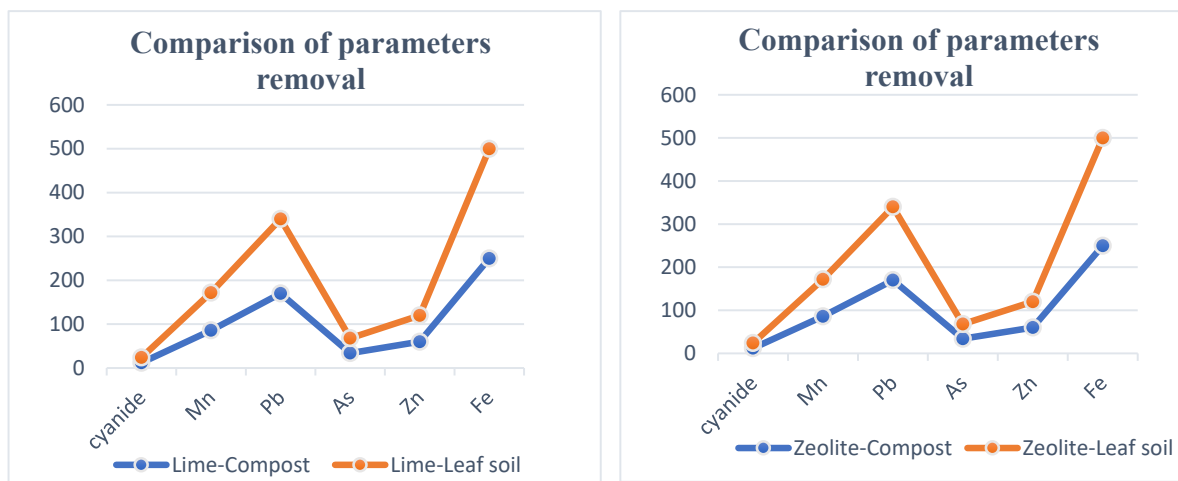


Figure 3. Graph comparison of parameters in fixed inorganic layer

at 249.93 removal units. As illustrated in Figure 3, and in conjunction with the data presented in Table 1, which outlines the input values for the pilot study, as well as Tables 10 and 13, which detail the output values of the parameters in the leaf soil-zeolite and zeolite-compost conditions, it can be inferred that a high level of efficiency has been attained in both scenarios, albeit with minor discrepancies. The aforementioned figure indicates a cyanide removal rate of 11.98 mg/L, alongside other parameters such as manganese at 85.99, lead at 169.98, arsenic at 33.995, zinc exhibiting a slight variation in both instances at 59.97, and iron at 249.94 removal units. It is also pertinent to note that for enhanced comparison and graph representation, the output interval values in Tables 10-13 were treated as constant figures. Based on the output interval values in Table 1, the removal rates of the parameters across different scenarios exhibit similarities, attributable to the selection of these values as the minimum removal rates.

To compare the present study with other recent studies, we can mention a study that used two specific types of clay to treat mineral wastewater. The findings indicated that the surface areas of the two anionic clays were measured at 64 m²/g for Koro and 50 m²/g for Kaya. Additionally, an anion exchange capacity of 126.68 cmol/kg was determined for Koro, while Kaya exhibited a capacity of 125.13 cmol/kg at a pH of 11 (Kabore et al, 2025). In another study, the adsorption of cyanide from the wastewater of gold processing plants using gilsonite were investigated, based on the obtained results, the maximum adsorption of 61.64% was obtained. With increasing adsorbent weight and mixing time, the cyanide adsorption rate was increased. This study indicated that gilsonite can be used as an isolation and absorbent in the structure and floor of the tailing dumps of mineral processing plants (Bahrami et al, 2020). In another study the adsorption efficiency of biowaste biochars for heavy metal ions from gold tailings wastewater was evaluated. The corn cob biochar demonstrated the ability to remove Cd (99.40%), Hg (90.50), Cr (15.60 to 75.60%), and Ni (21.30 to 84.50%). The peanut shell biochar also effectively removed Cd (99.10%), Hg (90.60%), Cr (19.10 to 77.80%), and Ni (35.50 to 85.30%). Meanwhile, the Sheanut shell biochar was able to remove Cd (99.10 to %), Hg (89.40 to 93.80%), Cr (8.90 to 73.30%), and Ni (35.50 to 87.10%) (Dwiejuah, 2025). In Cameroon, the wastewater of a gold mine and its mineral tailings were investigated and then an experiment was conducted on the effect of smectic clay absorbent. Adsorption test reveals that the maximum percentage removal is 60, 89, 55, -89.74, and 100 % for Cu, Zn, Mn, Fe and Pb respectively, after adding 0.5g of Sabga smectic clay (Luc Leroy et al, 2020). Another research presents the synthesis, characterization, and parametric optimization of copper-modified low-silica X (Cu-LSX) zeolite aimed at the effective removal of cyanide

ions (CN^-). The findings indicate that the optimization of process demonstrated an optimal CN^- removal efficiency of 96.7% (Wilessa et al,2026). Nano materials have also been used to check the effectiveness of removing cyanide compounds from wastewater. For example, study examined the removal of cyanide from synthetic wastewater by a new nano-adsorbent containing synthesized ZnO nanoparticles and copper-metal organic frameworks. The optimum values of removal efficiency achieved at pH = 6, the adsorbent weight of 0.4 g, temperature 25°C, contact time 60 min, and initial cyanide concentration of 10 mg/L were 65%, 76.5%, 68.5%, 67%, and 67%, respectively (Ghasemi & Rohani,2020).

The following Table 14 shows the basic cost paid for each of the adsorbents in proportion to their quantity and volume. These values are then compared with the cost of other adsorbents in other similar studies, which can be seen in the Table 15. To calculate the cost of each attractant in US dollars, the price of each of them has been changed from Iranian rials to US dollars in Table 14. In conclusion, based on the consumption levels of adsorbents and the associated costs outlined in the article, it is evident that these adsorbents can be categorized as cost-effective. Furthermore, to draw more comprehensive conclusions, future studies could investigate the influence of additional significant factors on the pricing of these adsorbents. In the Table 16 of calculated values, the statistical parameters of the data obtained from various experiments, including the Standard Deviation and Mean can be seen. Based on the statistical figures presented in Table 16, it can be inferred that the data at hand exhibit low dispersion as indicated by the standard deviation parameter.

Table 14. The basic cost of each adsorbent is based on the amount purchased

Adsorbents	Amount	USD/kg
Compost	1 bag of 25 kg	0.071
Zeolite	1 pocket of 25 kg	0.04
Lime	Cobblestone 3 kg	0.244
Leaf	1 bag of 2 kg	0.194

Table 15. The cost of treating wastewater using different adsorbent (Ighalo et al,2022)

Adsorbents	Adsorption Capacity(mg/g)	USD/g
Tomato Seeds	36.23	0.1180
Nano-zeolite	156.6	0.0300
Chitosan-calcite	21.36	0.2646

Table 16. The Statistical parameters

Statistical Parameters		Variables					
		CN	Mn	Pb	As	Zn	Fe
N	Valid	4	4	4	4	4	4
	Missing	0	0	0	0	0	0
	Mean	0.0020	0.0100	0.0650	0.0050	0.0113	0.0600
	Std. Error of Mean	0.00000	0.00000	0.04500	0.00000	0.00473	0.00408
	Median	0.0020	0.0100	0.0200	0.0050	0.0075	0.0600
	Mode	0.00	0.01	0.02	0.01	0.01	0.06
	Std. Deviation	0.00000	0.00000	0.09000	0.00000	0.00946	0.00816

CONCLUSION

On the basis of past research as well as the quantitative and qualitative nature of gold mine wastewater, pollutants such as cyanide, lead, arsenic, zinc, iron and manganese as target pollutants were determined in order to study the removal rate. the pilot system was also implemented so that two organic and inorganic layers were tested for several times with initial retention time between 12 and 24 hours to test their efficiency. the resultant of these tests is as follows:

- The combination of leaf and Zeolite demonstrates a removal efficiency of 99.8% for heavy metals and cyanide.
- Leaf and lime: in this instance, the removal efficiency for heavy metals and cyanide reaches 99%.
- The combination of compost and lime achieved a removal efficiency of 99% for heavy metals and cyanide in this instance.
- In this scenario, the removal rate of heavy metals and cyanide using zeolite and compost was found to be 99.8%.

Since natural adsorbents are usually disposable, this could be a serious limitation of this research. The main challenge requires separate research on the optimal management of these contaminated adsorbents. It is also necessary to investigate whether these contaminated adsorbents can be reused after their recovery. in order to make the research more mature, the following sections are presented:

- research on ways to reduce gold mine production during mining processes
- the study and use of processes that have minimum pollution.
- correct management and presentation of practical and economical solutions to control of tailings dumps.
- continual monitoring and production of the mine production sewer to gather information for the correct management
- similar pilot projects of this research in the semi - industrial scale and taking advantage of it
- test the treatment method to remove other pollutants and heavy metals

GRANT SUPPORT DETAILS

The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/ or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

This research involved working with significant amounts of heavy metals and cyanide.

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