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Removal of Metals in Wastewater by Applying Efficient Mountain Microorganisms and Sodium Hydroxide

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Wastewater is often a major problem for the environment due to its difficult treatment process and the damage it causes by contaminating the soil and water bodies where it is discharged. The objective was to remove metals in wastewater by applying mountain microorganisms and sodium hydroxide. The study site was in the district of Tarapoto, Province of San Martin. A total of 180 L of wastewater was used (9 samples), each sample contained 20 liters of water and was kept in a cold chain at an average temperature of 4 to 8°C for a period of 4 hours. The mountain microorganisms were reactivated and 20% sodium hydroxide was prepared. Three treatments were used (T1: MM 300 mL, T2: MM 400 mL, and T3: NaOH 20%). Analyses of 8 parameters were carried out and compared with the environmental quality standards category 3, showing that it exceeds the permitted values. The evaluation was carried out after 3 and 7 days and the results show that treatment 2, after 7 days of evaluation, reduces the values of the wastewater parameters and eliminates metals, complying with the environmental quality standards category 3 of the Peruvian Standard.

1. Introduction

Water is one of the renewable and limited natural resources whose function is the development of plant, animal and human life (Baquerizo et al., 2019). However, in some regions of the world water is scarce, due to population growth and the consequent domestic, industrial, agricultural, livestock, mining and other activities (Bolaños¬ et al., 2017, Gastañaga, 2018). In the world, more than 80% of wastewater is discharged directly into rivers or the sea, without considering a previous treatment to minimize its negative impacts on the water resource (WWAP, 2017). The main pollutants are physical, biological, microbiological and chemical substances such as inorganic metals (Latorre and Tovar, 2017, Canaza, 2018), which produce deterioration of a given body of water causing alterations in the chemical reactions of the metabolism of people, animals or plants related to the time of exposure and concentration (Schweitzer and Noblet, 2018) It is important to treat wastewater using different techniques or processes that help minimize contaminants such as inorganic metals (Chen et al., 2016, Sun et al., 2016). Bioremediation is a method to stabilize organic and inorganic compounds and improve water quality, through different physical and biochemical mechanisms (Ayme et al., 2022, Tejeda et al, 2022). Mountain microorganisms are a group of around 80 species of microorganisms that are found naturally in different ecosystems, without human intervention. These microorganisms include 10 genera belonging to 4 groups: photosynthetic bacteria, lactic acid-producing bacteria, yeasts, and actinomycetes. It is a liquid mixed culture of beneficial microorganisms, such as Rhodopseudomonas spp, Lactobacillus spp, Sacharomyces spp, actinomycetes and fermenting fungi, which have been captured from natural systems and have not been genetically modified. These microorganisms coexist symbiotically, producing positive effects for the environment and its balance.

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The use of these microorganisms can be beneficial in various fields (Singh et al., 2017); it can be considered economical compared to other techniques such as adsorption and filtration (Wan et al., 2016, Willscher et al., 2017). One technique to remove metals is the use of chemical solutions and microorganisms in order to meet water quality standards for the environment (Ang and Mohammad, 2020, Xue et al., 2021). Studies have been carried out confirming that beneficial microorganisms can have various positive effects, such as: increasing the nutritional value of food, reducing the presence of pathogenic bacteria to improve survival and reduce disease, maintaining and improving water quality by decrease the concentrations of ammonium, nitrite and nitrate, and reduce the load of organic matter. (Xue et al., 2018). In this sense, it is of utmost importance to manage water resources in rural areas, where it depends largely on the participation of communities in the management and use of the resource, so as to raise awareness about the care of the water resource (Delgado¬ et al., 2017, Li and Liu, 2019).In this sense, the objective of the research was to propose an alternative to remove metals in wastewater through the application of mountain microorganisms and sodium hydroxide.

2. Method

2.1. Area of study

This research was carried out in the district of Tarapoto, Province of San Martin, Department of San Martin, with UTM coordinates 349399.00 (East) and 9282533.00 (North).

2.2. Monitoring and collection of wastewater samples from the effluent

The volume produced by the effluent located in the district of Tarapoto is 1000 liters per day. A representative sample of 180 L of residual water is considered, the sampling of wastewater (9 samples) was carried out, each sample was 20 liters of water. The samples were kept in a cold chain at an average temperature of 4 to 8°C for a period of 4 hours in a cooler. Then, they were transported and processed in the Accredited laboratory - INACAL. (MINAGRI, 2016)

2.3. Preparation of Mountain Microorganisms (MM)

20 L of distilled water were used and 1 L of mountain microorganisms and 0.5 L of molasses were added. Subsequently, the mixture was left to rest for 6 days. The microbial respiration test was carried out, which consists of measuring the respiration rate of the microorganisms, glucose was used as a substrate, finally with this, verifying its activation. (Joergensen and Wichern, 2018)

2.4. Preparation of sodium hydroxide

Sodium hydroxide is a white, odorless, crystalline solid that rapidly absorbs carbon dioxide and moisture from the air (deliquescent). It is a very corrosive substance. The dilution was made using distilled water to obtain a proportion of 20% (Gonzales, 2010).

2.5. Experimental treatments

For mountain microorganisms (MM)
300 and 400 mL of mountain microorganisms were taken and poured into each container containing 20 L of effluent wastewater. The contents were mixed to make the components uniform and left to stand for 3 days and 7 days at room temperature. After the resting period, the respective samples were taken and sent to the laboratory for analysis.

2.6. For the Chemical Substance: sodium hydroxide (NaOH)

300 mL of the sodium hydroxide solution at a concentration of 20% was considered and poured over the container containing 20 L of effluent wastewater. The sample was mixed to homogenize it and left to stand for 3 and 7 days at room temperature. After the resting period, the respective samples were taken and sent to the laboratory for analysis.

2.7. Determination of efficiency

The metal removal efficiency, taking into account the control group and the experimental groups, as detailed below:

$$\text{Removal efficiency (\%)} = \left[\frac{EGCfinal - EGCinicial}{EGCfinal}\right] \text{ x } 100 \quad (1)$$

Where:
EGCfinal: Parameters measured in days 3 y 7.
EGCinicial: Parameters measured in days 0.
EGC: Experimental group concentration

2.8. Statistical analysis

Parameters were calculated for the control and experimental groups, and the averages and efficiency percentages were used to identify the significant differences between each of the treatments.

3. Results

Table 1: Analysis of wastewater from the effluent without treatment

Parameter	Unit	Results	ECA- Water/category 3	
			Irrigation of vegetables	Drinks for animals
Oils and fats	mg/L	150	5	10
Biochemical oxygen demand	mg/L	180	15	15
Chemical oxygen demand	mg/L	125	40	40
Aluminum	mg/L	28	5	5
Cadmium	mg/L	3.2	0.01	0.05
Copper	mg/L	2.8	0.2	0.5
Chrome	mg/L	2.4	0.1	1
Zinc	mg/L	5.1	2	2.4

The following parameters were found: oils and fats 150 mg/L, biochemical oxygen demand 180 mg/L, chemical oxygen demand 125 mg/L, aluminum 28 mg/L, cadmium 3.2 mg/L, copper 2.8 mg/L, chrome 2.4 mg/L, zinc 5.1 mg/L. The values obtained were compared with the environmental quality standards category 3 (Peruvian standard) and it was found that all the results exceeded the permitted range.

Table 2: Analysis of wastewater with the treatments after 3 days

Parameter	T1: MM 300mL	T2: MM 400mL	T3: NaOH 20%	ECA- Water/category 3	
				Irrigation of vegetables	Drinks for animals
Oils and fats (mg/L)	108	32	75	5	10
Biochemical oxygen demand (mg/L)	114	61	53	15	15
Chemical oxygen demand (mg/L)	101	42	61	40	40
Aluminum (mg/L)	21	13	23	5	5
Cadmium (mg/L)	2.5	1.02	2.8	0.01	0.05
Copper (mg/L)	1.9	1.1	2.1	0.2	0.5
Chrome (mg/L)	1.7	1.1	1.9	0.1	1
Zinc (mg/L)	3.1	1.8	3.6	2	2.4

According to the parameters analyzed and compared with the category 3 environmental quality standards (Peruvian norm), they exceed the permitted range.

According to the analysis, it is observed that in treatment 2, the values of the wastewater parameters decrease significantly, complying with the category 3 environmental quality standards of the Peruvian Standard. Mountain microorganisms are of great importance for wastewater remediation due to their ability to degrade various organic and inorganic contaminants present in water (Jiang et al., 2021); these microorganisms are capable of adapting to extreme environmental conditions, such as low temperatures and lack of nutrients, which allows them to survive in mountain aquatic systems and carry out processes of biodegradation and removal of polluting substances in the water (Wang et al., 2020)

Table 3: Analysis of wastewater with the treatments after 7 days

Parameter	T1: MM 300mL	T2: MM 400mL	T3: NaOH 20%	ECA- Water/category 3	
				Irrigation of vegetables	Drinks for animals
Oils and fats (mg/L)	39	8	31	5	10
Biochemical oxygen demand (mg/L)	41	14	28	15	15
Chemical oxygen demand (mg/L)	54	21	42	40	40
Aluminum (mg/L)	12	4	19	5	5
Cadmium (mg/L)	1.2	0.03	1.9	0.01	0.05
Copper (mg/L)	1.2	0.3	1.7	0.2	0.5
Chrome (mg/L)	0.8	0.2	1.6	0.1	1
Zinc (mg/L)	1.9	1.1	2.9	2	2.4

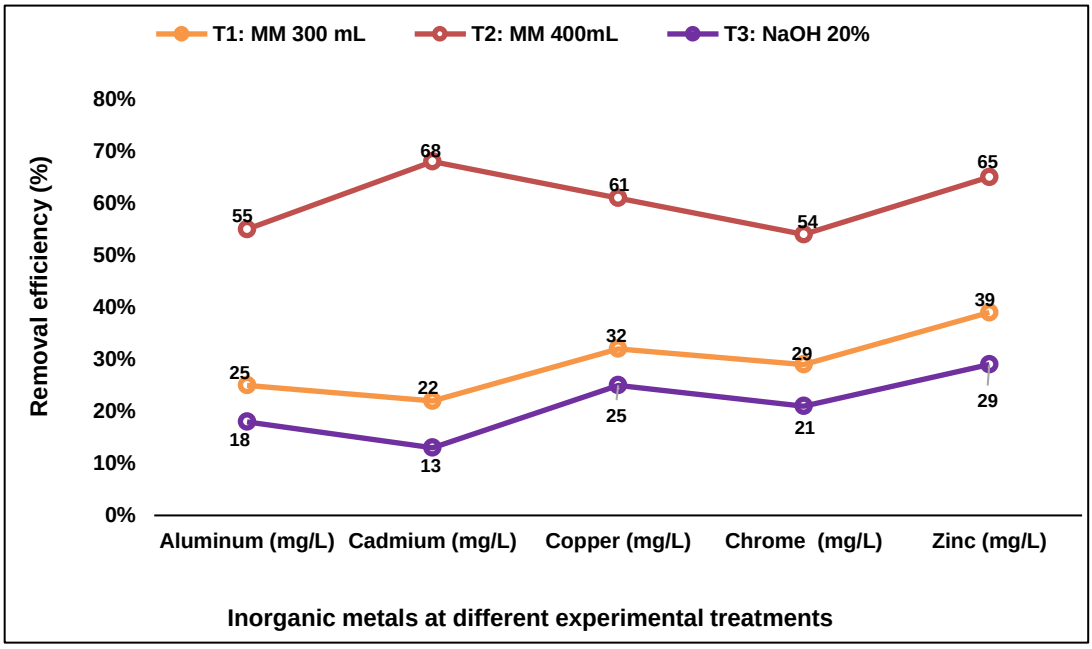

Figure 1: Percentage of metal removal efficiency at 3 days

The results are shown in T1: (MM 300 mL) aluminum 25%, cadmium 22%, copper 32%, chrome 29%, zinc 39%; in T2: (MM 400 mL) aluminum 55%, cadmium 68%, copper 61%, chrome 54%, zinc 65%; in T3: (NaOH 20%) aluminum 18%, cadmium 13%, copper 25%, chrome 21%, zinc 29%. Treatment 1 and 2 remove the metals by weighing, being an alternative to use in future research.

The experimental treatments at 7 days in T1: (MM 300 mL) aluminum 57%, cadmium 63%, copper 57%, chrome 67%, zinc 63%; in T2: (MM 400 mL) aluminum 86%, cadmium 99%, copper 89%, chrome 92%, zinc 79%; in T3: (NaOH 20%) aluminum 32%, cadmium 41%, copper 39%, chrome 33%, zinc 43%. Mountain microorganisms have also demonstrated their ability to remove heavy metals in water, including cadmium, copper, zinc, nickel, lead, mercury, and chromium these microorganisms have the ability to adsorb and precipitate heavy metals in their cells and in the products of their metabolism, as well as transform them into less toxic forms for the environment (Sari et al., 2021); in addition, it has also been found that these microorganisms can increase the effectiveness of other heavy metal removal methods in water, such as chemical precipitation and electrocoagulation (Dubey et al., 2021)

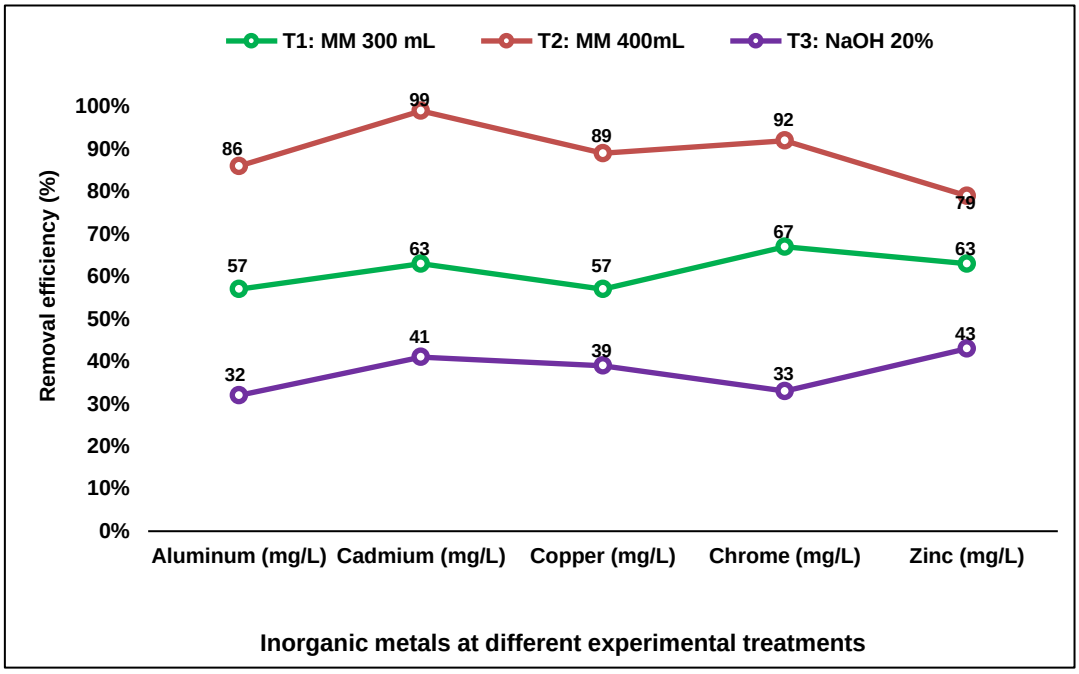

Figure 2: Percentage of metal removal efficiency at 7 days

4. Conclusions

A sample of wastewater was analyzed, obtaining the result of 8 parameters. Among them, inorganic metals, compared with the Peruvian norm of quality standards, the values exceed the permitted ranges.

Three experimental treatments were applied and evaluated at 3 and 7 days with the purpose of eliminating heavy metals from wastewater. It is evident that treatment 2 decreases the values of wastewater parameters, complying with the environmental quality standards category 3 of the Peruvian Standard.

Finally, treatment 2 at an evaluation of 7 days has a high percentage of metal removal, being an alternative for the treatment of wastewater discharges from effluents.

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