Section A-Research paper
ISSN 2063-5346

ANALYSIS OF THE HYDROLOGICAL INFORMATION AND INVENTORY OF WATER SOURCES AT THE STUDY MINE

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ABSTRACT

This paper analyzes the hydrological information and also makes an inventory of water sources in the study mine, in order to determine the effects that they can cause in the surface and underground basins of the area, take into account that the mining unit is influenced by Formation 2, likewise, the two main streams in the study area are Stream 1 to the north and Stream 2 to the south. Streams with low flow flow through these ravines most of the year, except in the rainy months.

Perforations of 8 piezometers were carried out with well depths of 100 and 50 meters, the diameter of the wells of 2 1/2 inches and perforations of 4 1/2 inches in diameter. Adding the study has contemplated the use of 4 weather stations controlled by the National Service of Meteorology and Hydrology of Peru, which cover the entire area of the study area, which are: Station A, B, C and D, was also carried out the calculation of potential evapotranspiration by the Thornthwaite method and the location of groundwater and surface water sources was determined.

The data on flow, pH, temperature, salinity, total dissolved solids and electrical conductivity were also analyzed, comparing the results of surface and groundwater sources with the Environmental Quality Standards for Water approved by Supreme Decree No. 004-2017. -MINAM, specifically for Category 3. As a result, the climatology in the study area has a

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seasonal behavior where the highest rainfall in the year occurs in the months of February, March and April, due to the union of the climatic factors analyzed.

Keywords: piezometer; hydraulics; inventory; Broken; Temperature; salinity; total dissolved solids; electric conductivity.

INTRODUCTION

In recent years, the mining industry has been developing its activities in scenarios in which the access and use of water constitute it not only as a resource with which they carry out mining-metallurgical processes, but also turns out to be a determining factor to position itself as an actor together with others in the basin, with whom it has to establish agreements not only of use but also of shared management, on the basis of technical-normative procedures indicated by the competent authority in the field of water resources (Science et al., 2023) . As such, water plays a crucial role in most modern industrial mining operations, as it is a resource involved in numerous intermediate processes. (Cetaqua, 2019).

Mineral extraction requires large amounts of water, which can lead to a decrease in the level of aquifers and contamination of surface and underground water resources. The mining activity in its operations adopts water conservation mechanisms, which have to do with the management of the quantity and its access (Espinar, 2013) . Therefore, it is crucial to conduct hydrogeological studies to assess the aquifer potential of these areas and determine the impact of mining activity on local water resources.

The two main streams in the study area are Quebrada 1 to the north and Quebrada 2 to the south, the evaluation of the aquifer potential of the mining unit, a combination of field techniques and data analysis was used to determine the delimitation of micro-basins around the study mine. Drilling and 8 piezometers were drilled and installed to determine hydraulic parameters and groundwater quality at the mining unit.

The participation of the mining activity as active support in the elaboration of hydrological and diagnostic studies in the basins of influence, implementing management-optimization models, prior to the materialization of investment plans is an issue to be seriously addressed and properly planned. On the other hand, the Environmental Quality Standards (ECA) are regulations that define the acceptable levels of pollutants or quality parameters in different environmental media, in this case the water is analyzed and Supreme Decree No. 004-2017-MINAM is a regulation issued by the Ministry of Environment of Peru, which establishes the Environmental Quality Standards (ECA) in Peru.

MATERIALS AND METHODS

2.1. Lithology and stratigraphy

This section presents the geological characteristics of the mining unit, the importance of the geological issue lies mainly in the hydrogeological conditions that affect the project, the mining unit is influenced by Formation 2, made up of clastic rocks eroded on the limestones of the Jumasha Formation and at the top is covered by the pyroclastic volcanic series of Formation 1.

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On the other hand, Formation 2, of continental environment, locally has been divided into a lower member called Member 1 and an upper member called Member 2. It is considered the oldest formation that occurs in the field. It forms the broad anticlinal, which is crossed by the river 1 and is composed of sedimentary rocks that are of common environment (INGEMMET, 1982) (Arroyo et al., 2019) .

Formation 2, covers the oldest formation that emerges in this area, its slope is River 1 which generated sedimentary rocks such as limestone. Where several masses were formed. Member 1 presenting shales and calcareous sandstones, acquiring a reddish coloration that is currently observed sporadically (Acuña & Torres, 2021) . Formation 1 is a sequence of volcanic-sedimentary rock that lies, in apparent agreement, on Formation 2. This formation is divided into three members: Member 3, Member 4 and Member 5 (Rojas et al., 2016) . The Membro 5 of study, is characterized by reddish tuffs with some intercalations of lapillitic tuffs greenish gray, and brown; occasionally layers of andesites, siltstones and tobaceous sandstones are present (Surichaqui, 2021) .

2.2. Structural and geomorphological aspects

Structurally the study area is affected by folds and callamientos, which have caused the formation of anticlines and synclines, causing the fracturing and rearrangement of the original structure of the rock units, causing diaclase fractures that in turn have generated a secondary porosity, which is an important element for hydrogeology to cause an increase in the permeability of the original rocks. The study mine, from the point of view of geomorphology is located on the upper floor of the Western Cordillera of the Andes, between 3600 to 5000 meters above sea level. Geomorphological features are the result of tectonic processes and exogenous processes.

2.3. Hydrogeological aspects

The Rio 1 basin is the main tributary that has contact with the study area, it is more prone to undergo changes due to mining activities, streams, springs and micro-basins located around. It is located on the western slope of the Andean mountain range at coordinates UTM 306350 E, 8674032 N. It has a length of 140 km, a dimension of 3312 km2 and a flow of 45 m3 / s. During the year of study, the Upper Basin is being impacted by the mining activities developed in the area, which can cause affections in the local community, surrounding populations (Bedregal et al., 2010) and important cities that surround its channel.

Low flow streams run through the study mining unit most of the year, except in the rainy months, the soils have surfaces with little vegetation cover. The study area is circumscribed mostly in the regional geomorphological unit called valley and a small percentage in the geomorphological region called highland zone, the two main streams in the study area are to the north the Quebrada 1 and to the south the Quebrada 2, as can be seen in (***Figure 1***).

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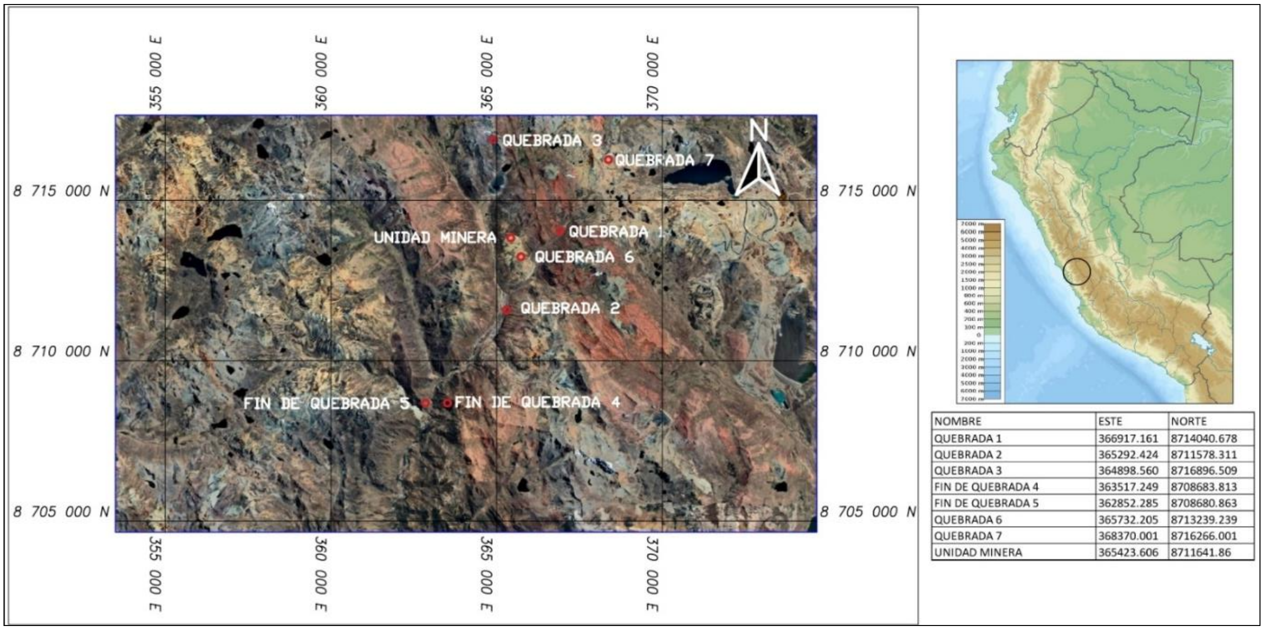
Figure 1. *Location of the study mining unit*



NOMBRE	ESTE	NORTE
QUEBRADA 1	366917.161	8714040.678
QUEBRADA 2	365292.424	8711578.311
QUEBRADA 3	364898.560	8716896.509
FIN DE QUEBRADA 4	363517.249	8708683.813
FIN DE QUEBRADA 5	362852.285	8708680.863
QUEBRADA 6	365732.205	8713239.239
QUEBRADA 7	368370.001	8716266.001
UNIDAD MINERA	365423.606	8711641.86

Source: *Google Earth 2023.*

2.4. Climate

The study mine presents a moderately rugged topographic relief, with geoforms that denote an advanced state of maturity, where there are wide ravines. The shapes adopted by the water courses mean that the area is cut by two directional systems of streams, to which the smaller ones converge. The climate from May to November is a dry season, almost uniform temperature, rains are sporadic presenting in the month of June an intense cold, accompanied by frosts during the night (Ricaldi & Domingo, 2018) (Mitma, 2019) . On the other hand, the rainy season is between the months of January to March characterized by heavy rainfall with a temperature of 10 ° C and decreasing to 0 ° C, the rest of the year is characterized by a temperate dry climate (Castro, 2005) .

2.5. Drilling and installation of piezometers

The drilling was carried out with a diamond and reverse air drilling machine, with a drilling diameter of 41/2 inches and 08 control piezometers will be drilled to determine the hydraulic parameters and quality control of groundwater, in the area of influence of the mining unit. The installation of the piezometers will be carried out under the control of the company's specialist personnel complying with the Standard Operating Procedure (SOP), necessary to guarantee the quality and safety of the installation of control piezometers.

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2.6. Technical characteristics of wells

Depth and diameter of wells

The depth of the wells proposed in this report is as follows, 100 metres (PZM-01, PZM-02 and PZM-03) and 50 metres (PZM-04, PZM-05, PZM-06, PZM-07 and PZM-08), the diameter of the wells located in the mining unit is 2 1/2 inches, which will be installed by drilling 4 1/2 inches in diameter, the technical characteristics measured in the piezometers are shown in (***Table 1***).

Table 1. *Technical characteristics of drilling and installation of piezometers*

COD	Location	Land Elevation (masl)	Perforation		Installation	
			Prof. (m)	Diam. (in)	Prof. (m)	Diam. (in)
PZM-01	Quebrada 1	4410	100	4 ½	100	2 ½
PZM-02	Surroundings Mine	4693	100	4 ½	100	2 ½
PZM-03	Camping Environment	4171	100	4 ½	100	2 ½
PZM-04	Camping Environment	3993	50	4 ½	50	2 ½
PZM-05	Quebrada 3	4394	50	4 ½	50	2 ½
PZM-06	Quebrada 3	4246	50	4 ½	50	2 ½
PZM-07	End of Quebrada 4	4143	50	4 ½	50	2 ½
PZM-08	End of Quebrada 5	3225	50	4 ½	50	2 ½

2.7. Location of Weather Stations

This study refers to climatological parameters that are applied in Hydrology, interested in the influence of meteorological phenomena on the components of the hydrological cycle especially precipitation, evapotranspiration and temperature The rainfall network used in the study area is made up of 4 stations controlled by SENAMHI, which have a height of: A (4479 masl), B (4214 masl), C (3866 masl) and D (2479 masl) near the study area, the stations in question continue to record data at present, it should be noted that the stations represent well the characteristics of the area in which the study mining unit is located. (ANA, 2022).

RESULTS

3.1. Climatology

The study has contemplated the use of 4 climatological stations controlled by SENAMHI, which cover the entire scope of the study area, which are: (Station A, Station B, Station C and Station D). For the purposes of this study, data from station A will be used, so the study of climatology has become a dynamic science with a wide range of applications and new techniques are developed over time and new fields of application are included.

3.1.1. Climate parameters

Precipitation

Precipitation is the main source of water for surface and underground currents, the study area presents the following total monthly rainfall (annual average) for each of its stations, which are:

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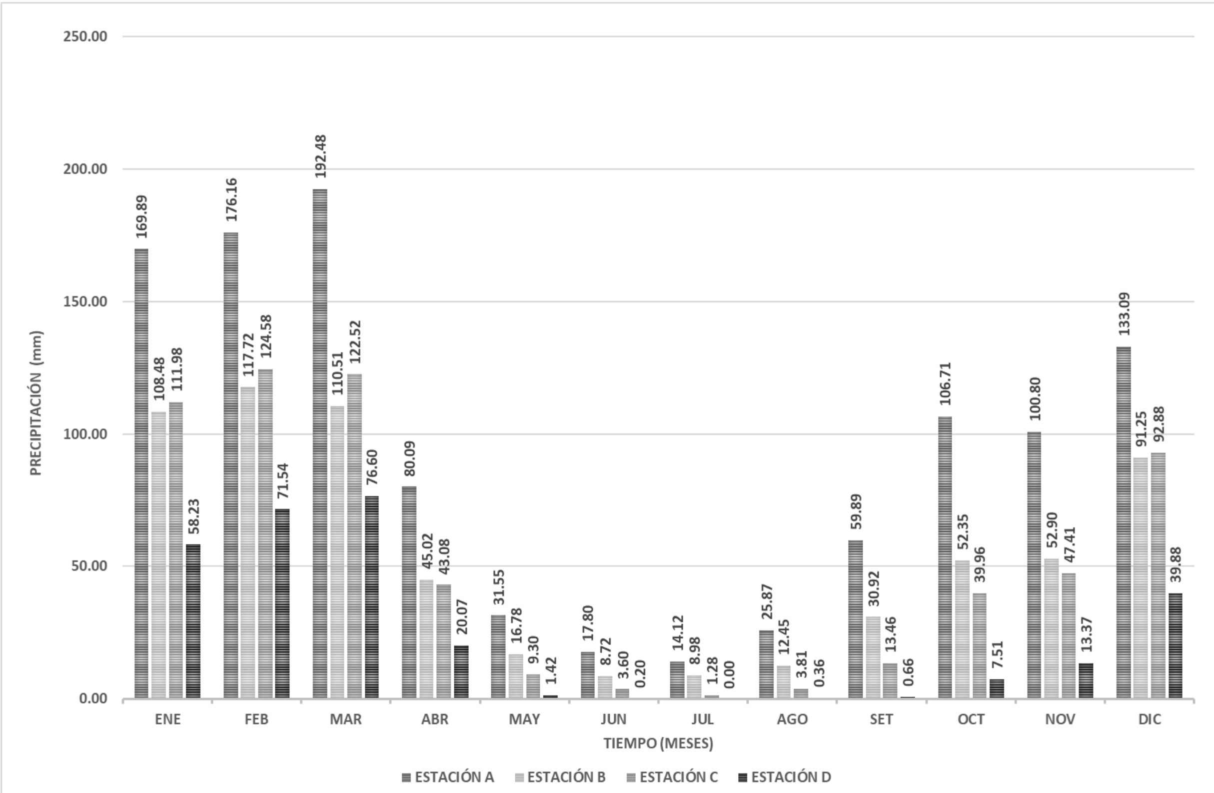
(Station A: 1108.4 mm), (Station B: 656.1 mm), (Station C: 613.9 mm), (Station D: 289.8 mm). Below is a comparison of the rainfall of the stations in the study area ***(Figure 2)***.

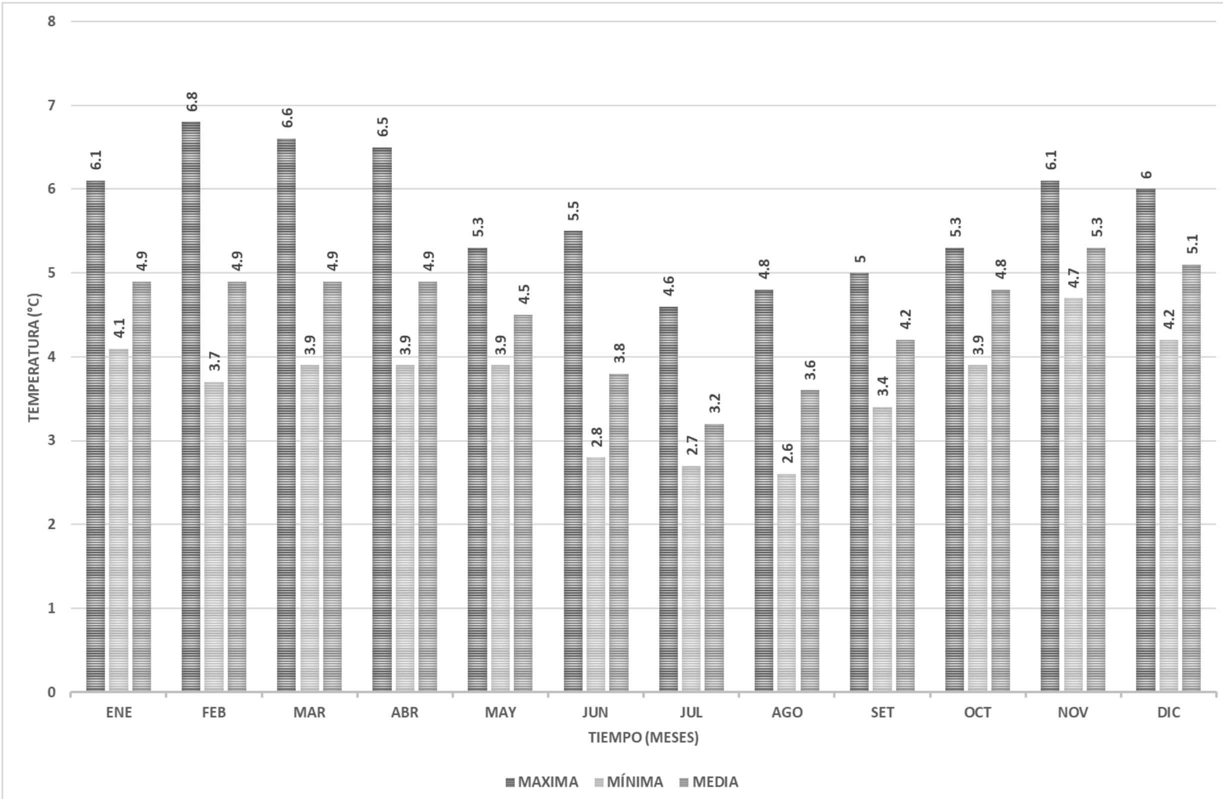
Figure 2. *Comparison of Precipitation Variation by Seasons*



Temperature

For the purposes of this study, the temperature data recorded in station A has been considered, the highest temperature peaks occur for the months of February, March and April where they oscillate between 6 and 7 ° C, and the minimums for the month of June, July and August, data ranging between 2 and 3 ° C, Within the study of these oscillations with respect to the values, it is of particular importance to know the probability of the appearance of periods characterized by a succession of high or reduced temperature values, in addition to the fact that when the air temperature drops to zero degrees Celsius or lower values in high Andean areas, they usually begin in April and end in September, reaching its coldest period in the months of June and July as shown in (***Figure 3***).

Figure 3. *Comparison of monthly temperature variation*

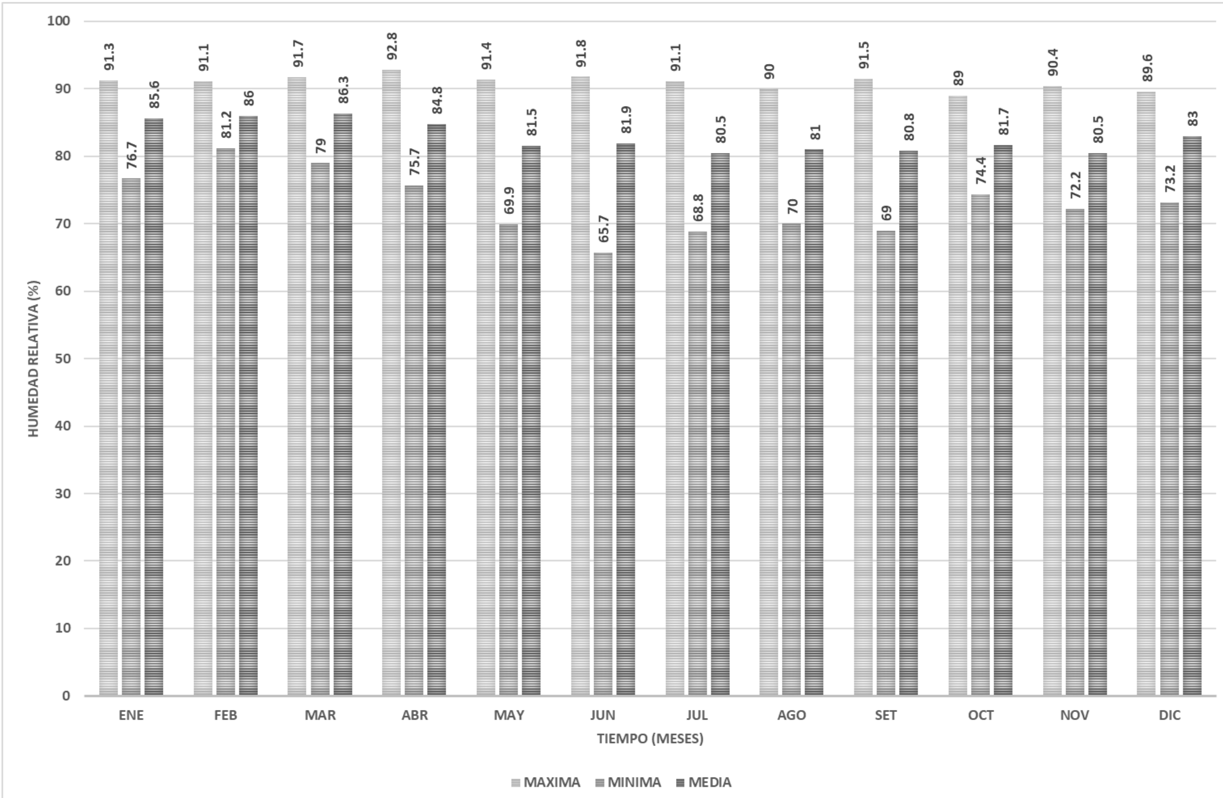


Relative humidity

In general, the average annual relative humidity decreases with altitude, taking higher values in low areas and lower values in the high areas of the basin. This variable, like temperature, is directly related to altitude, that is, average annual relative humidity levels decrease with altitude, in addition the main meteorological parameters that define or characterize the climate in the study area are: precipitation, temperature, relative humidity.

For the study of this element, there is information from Station A, in which there is a minimum registered Relative Humidity of 65.7%, and the maximum relative humidity registered is 92.8%, which indicates that in high Andean areas there is also enough humidity that coupled with the seasonal decrease in temperature and configure a humid and cold climate. In addition, that the environmental humidity in the area restricts the occurrence of sudden decreases in environmental temperature, however, in the month of March and April a slight increase in relative humidity was observed, this variation is shown below in ***(Figure 4).***

Figure 4. *Comparison of monthly relative humidity variation*



Evapotranspiration

For the calculation of evapotranspiration was used empirical method of Thornthwaite where the monthly mean temperature is used, to estimate the monthly potential evapotranspiration. From these calculations, an estimate can be obtained of the amount of water that would evaporate and transpire in the unsaturated zone as a reservoir, which is filled by infiltration and emptied by evapotranspiration. The calculation of monthly evapotranspiration is an averaged and simplified representation of the actual climate water balance. However, the method shows less accuracy when comparing data on a monthly basis, especially with regard to snow melt runoff.

The basic information to determine the potential evapotranspiration comes from the climatic data of the stations, in this way taking into account the series of monthly temperature data, the calculation of the monthly potential evaporation was carried out by the Thornthwaite method, showing as a result an annual thermal index (I) = 10.3432, exponent (a) = 0.67024 and annual ETP = 527.11, the results are shown below in (***Table 2***).

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Table 2. *Calculation of potential evapotranspiration Thornthwaite method*

Months	Temperature (°C)	Monthly heat index	Theoretical ETP (mm)	Factor f	Number of days per month	(days/30)	ETP (mm/month)
January	4.94	0.982	45.631	1.08	30	1.00	49.282
February	4.86	0.958	45.134	0.97	30	1.00	43.78
March	4.88	0.964	45.259	1.05	30	1.00	47.52
April	4.91	0.973	45.445	0.99	30	1.00	44.99
May	4.53	0.861	43.057	1.01	30	1.00	43.49
June	3.75	0.647	37.935	0.96	30	1.00	36.42
July	3.25	0.521	34.465	1.00	30	1.00	34.47
August	3.62	0.613	37.048	1.01	30	1.00	37.42
September	4.20	0.768	40.928	1.00	30	1.00	40.93
October	4.82	0.946	44.885	1.06	30	1.00	47.58
November	5.29	1.089	47.773	1.05	30	1.00	50.16
December	5.07	1.021	46.432	1.10	30	1.00	51.08

3.2. Results of physico-chemical parameters of groundwater sources

The Inventory of Groundwater Sources is an important tool for decision-making in the management of water resources, for purposes of water use, control and monitoring of quantity and quality, in total 29 sampling points have been inventoried taken throughout the study mine, groundwater is very important as a water resource since it constitutes the largest reserve of accessible fresh water, On the other hand, the quality of groundwater responds to a series of properties such as pH, Temperature, Salinity (S), Total Dissolved Solids (TDS), Electrical conductivity (EC).

The sampling points indicate that for BX-004 it has a maximum flow of 49.3 l / s at temperatures of 9.5 ° C and for BX-029 it has a maximum flow of 0.4 l / s at temperatures of 11.4 ° C, the general objective of the inventory is to record in a time and space all groundwater sources, as of all those hydraulic structures of access to the groundwater source, and create or update a systematized database that is useful for the management of groundwater resources, the following table shows the sampling points with their corresponding flows (***Table 3***).

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Table 3. *Physicochemical parameters of groundwater sources (sampling points at the study mine)*

Sampling points	Progressive	Flow rate (l/s)	pH	Temperature (°C)	S (ppm)	TDS (ppm)	CE (µS)
BX-001	0+000	29.3	7.9	9.4	727	1024	1475
BX-002	0+075a	48.5	7.9	10.6	666	947	1370
BX-003	0+075b	0.5	8	10	723	1011	1453
BX-004	0+090.8	49.3	8	9.5	719	1008	1444
BX-005	0+188.8	49.1	7.9	9.7	686	970	1391
BX-006	0+416.3	32.8	7.6	9	652	937	1375
BX-007	0+520.4	25.4	8.9	10.4	698	984	1409
BX-008	0+600	21.6	8	10.3	716	1003	1460
BX-009	0+795	17.5	7.9	10.8	860	1212	1725
BX-010	0+867.4	20	8	9.3	263	370	528
BX-011	0+918	18	7.8	10.8	393	1264	1806
BX-012	0+950	21	7.9	10.5	930	1299	1857
BX-013	0+970	18.5	7.7	11.2	909	1278	1829
BX-014	0+996.7	16.3	7.8	11.5	922	1296	1866
BX-015	1+074.3	29.8	7.5	12.3	663	929	1329
BX-016	1+189.6	14.7	7.9	11.5	930	1309	1871
BX-017	1+275	10.4	7.81	11.1	1010	1430	2070
BX-018	1+425	17.2	7.83	11	971	1362	1951
BX-019	1+600	16.6	7.85	11	985	1379	1970
BX-020	1+918.7	11.2	7.48	11.5	1090	1570	2250
BX-021	1+975	7.6	7.65	11.6	1060	1520	2220
BX-022	2+107	7.2	8.29	11.9	1120	1670	2370
BX-023	2+250	5.2	7.8	11.6	809	1133	1619
BX-024	2+350	5.7	7.65	10.2	862	1220	1763
BX-025	2+375	4.1	7.84	10.1	884	1237	1768
BX-026	2+443.6	2.8	7.46	9.6	757	1065	1541
BX-027	2+531.5	1.4	7.68	11.1	977	1367	1950
BX-028	2+654	0.6	7.73	11.8	968	1400	1965
BX-029	2+782	0.4	7.59	11.4	972	1412	1972

3.3. Results of physico-chemical parameters of surface water sources

The first stage of the inventory of gauging was carried out along the channels of the rivers and springs, for this it was necessary to have technical and specialized personnel. In total, 08 sampling points of field parameters have been inventoried, likewise the location of the sampling points of the surface water sources, Ground Level, pH, Temperature, Salinity (S), Total Dissolved Solids (TDS), Electrical conductivity (EC), of which the values are shown in the following (***Table 4***).

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Table 4. *Physicochemical parameters of surface water sources (Capacity in channels and springs).*

Code	Location	Land Elevation (masl)	pH	Temperature (°C)	S (ppm)	TDS (ppm)	CE (µS)
Q6_01	Quebrada 6	4550					
Q6_02	Quebrada 6	4372	8.4	6.1	180	258	373
R1_01	Rio 1	4409	8.5	6.5	193	273	396
Q6_03	Quebrada 6	4367	8.4	10	202	288	416
R1_02	Rio 1	4239	8.7	10	197	277	399
Q7_01	Quebrada 7	4235	8.6	8.7	299	405	585
Q2_01	Quebrada 2	4200	8.2	10.3	635	889	1276
ME_01	Spring Pier	4212	7.8	13.13	543	749	1078

DISCUSSIONS

Relative humidity indicates the percentage of vapour dissolved in a volume of air by reason of the vapour required to saturate it; or, indicates the ratio of the vapor pressure to the saturation vapor pressure. The relative humidity decreases the higher the height above sea level, the area under study is located on the upper floor of the Western Cordillera of the Andes, between 3600 to 5000 meters above sea level and has a high relative humidity most of the year, it is observed that the height above sea level is an important factor, but it also affects the proximity to wet sources and the geomorphology of the terrain; The study area is surrounded by several streams which significantly influence the relative humidity and has a rather rugged geomorphology. (Mendez et al., 2017)

Evapotranspiration represents water removed from soil and vegetation into the atmosphere. For this reason, the estimation of this parameter is essential in the study of hydrological processes. (Marini et al., 2017) In the results of evapotranspiration of the study there is a direct relationship with the average monthly temperature, as the temperature increases, potential evapotranspiration also tends to increase, in the months from November to March the highest values are obtained and the lowest values are obtained In winter, which would be from June to August, this direct influence of temperature on the results is largely due to the method that was used for the calculation.

The Thornthwaite method is widely used, however, it is based solely on temperature data. This type of methods, although it is true that they are simpler and easier to apply, they are less precise and to obtain results with better precision, he recommends combined methods such as the Pennam method, but these require a greater amount of meteorological data. (Back, 2008) On the other hand, precipitation must be taken into account when analyzing the values of potential evapotranspiration, if precipitation is low there will be a lower availability of water in the soil and this would lead to limitations for evapotranspiration, consequently, actual evapotranspiration could be less than potential evapotranspiration, since vegetation and soils would not obtain enough water for evaporation and transpiration.

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It is important to keep track of monthly rainfall because it helps to understand the variability in climate and precipitation patterns in this study area. The information collected from these records can provide crucial data for water resources management, flood risk assessment and infrastructure decision-making. According to a research paper published by the University of Nevada, Reno, "With the collection of precipitation data, one can estimate the amount of potential water that can infiltrate the soil and recharge the underground aquifer." (Ashouri et al., 2015) The variation in rainfall can be influenced by various factors, such as geographical location, topography of the study area, regional climate, wind, humidity and other climatic variables, in addition it can also be influenced by long-term weather patterns, such as the El Niño and La Niña phenomenon.

Variations in Pacific ocean temperature, known as El Niño and La Niña, are one of the main causes of variability in rainfall in South America. During an El Niño event, tropical Pacific temperatures rise, which can lead to an increase in the amount of precipitation in some areas and a decrease in others. On the other hand, during a La Niña event, tropical Pacific temperatures decrease and an increase in the amount of precipitation is expected in some areas. The topography of the study area can also affect rainfall, as mountains can block the entry of wet winds, reducing the amount of precipitation in leeward areas. The presence of water bodies can also influence the amount of precipitation, as evaporation can contribute to cloud formation. (SENAMHI, 2023) (Vuille, et al., 1999)

In the case of temperature, it indicates that data from SENAMHI Station A in the Junín region show that the maximum and minimum temperatures recorded vary according to the month. According to the theory of inverse proportionality, which applies to the behavior of temperature and atmospheric pressure, these data suggest that temperature could be affected by atmospheric pressure at different times of the year. It is important to keep track of the average monthly temperature in a given study area because temperature is a key factor in many important processes, such as evapotranspiration, photosynthesis, and seed germination. In addition, temperature can affect the distribution and diversity of ecosystems.
From the results of the physicochemical parameters of groundwater sources, they yield important physicochemical parameters, one of them is the electrical conductivity is commonly used to evaluate water quality as an indicator of pollution, as an increase can be indicative of the presence of contaminants such as salts, heavy metals or excess nutrients. The most notable effects of a misuse of irrigation water are the salinization and sodification of soils that lose their structure and the ability to withstand new agricultural cycles (Garcia, 2015) . And it could be detrimental in the agricultural irrigation of areas surrounding the study area and drinking water supply.

With respect to the electrical conductivity parameter, a maximum value of 2370 µs/cm corresponding to the BX-022 capacity is shown, in addition to the minimum value of 528 µs/cm corresponding to the BX-010 capacity and based on the ECA of Cat 3-D1 should not exceed 2500 µS/cm and Cat 3-D2 should not exceed 5000 µS/cm. of the Cat 3-D1 and 2630 µS/cm below the ECA of the Cat 3-D2 it is remarkable to consider that the level of electrical conductivity is natural in water and does not represent a problem in itself.

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The indicator measure of the level of acidity or alkalinity of a substance has a great relevance in the quality of the water resource, an inadequate pH can affect the survival, growth, reproduction and health of aquatic organisms, such as fish, invertebrates and aquatic plants. An extremely acidic pH can cause mortality of aquatic organisms, while a high pH can affect the availability of nutrients essential for their growth and development. From the data obtained in the field, corresponding to the chemical parameter of pH, a maximum value of 8.8 corresponding to the BX-007 capacity and a minimum value of 7.46 corresponding to the BX-026 capacity have been obtained.

In accordance with Supreme Decree No. 004-2017-MINAM, based on the ECA of Cat 3-D1 and Cat 3-D2, the capacity sample BX-007 is 0.3 above the ECA of Cat 3-D1 and 0.4 above Cat 3-D2. The presence of alkaline substances, such as carbonates, can be highlighted and is demonstrable because the study area is located in Formation 2, which is in erosional discordance on the limestone rocks of the Jumasha Formation. The total dissolved solids in the water indicates the amount of dissolved substances present in the samples taken in the study area, note that this parameter as electrical conductivity are used to evaluate water salinity, salt concentration and overall water quality.

High values of electrical conductivity and total dissolved solids may indicate the presence of contaminants or a high concentration of salts in the water. From the information obtained in the field corresponding to the total dissolved solids parameter, a maximum value of 1670 ppm is shown in the BX-022 capacity and a minimum value of 370 ppm corresponding to the BX-010 capacity. The ratio of electrical conductivity (EC) is directly proportional to the content of total solids dissolved in groundwater and these increase with the evolution of groundwater (Silva et al., 2013) . Therefore, the data have a direct relationship with electrical conductivity, because having a greater amount of dissolved solids in water, the concentration of ions increases, therefore, the electrical conductivity will increase.

Salinity as a measure of the concentration of dissolved salts, mainly chlorides, sulfates and carbonates, is important due to its effects on water quality, agriculture and aquatic organisms, among others. High concentrations of salts can interfere with the absorption of essential nutrients, cause root damage and reduce crop productivity. From the data obtained in the field in the salinity parameter, a maximum value of 1120 ppm is shown in the BX-022 gauge, and a minimum value of 263 ppm corresponding to the BX-010 gauge. Quantitative salinity is measured through the electrical conductivity (EC) of the waters (Carrera et al., 2015) . And the relationship between electrical conductivity and salinity is directly proportional, because as the concentration of dissolved salts increases, the electrical conductivity will also increase. However, it is important to mention that the relationship between salinity and electrical conductivity could vary depending on the types and proportions of salts present in the water.

From the data obtained in the field, corresponding to the temperature parameter, a maximum value of 12.3 ° C corresponding to the capacity point BX-015 has been obtained, and a minimum value of 9 ° C corresponding to the capacity point BX-009. According to Supreme Decree No. 004-2017-MINAM, based on the ECA of Cat 3-D1 and Cat 3-D2, it must be within the variation of 3° C. The temperature in the study unit is 10°C and measurements made at sampling points fall within the acceptable range of 3°C indicated in the ECA temperature parameter of Cat 3-D1 and Cat 3-D2.

From the results of the physicochemical parameters of the surface water sources, the value obtained for the Electrical Conductivity in the field, there is a maximum value of 1276 µs / cm for the sampling point Q2_01 located in Quebrada 2, a minimum value of 373 µs / cm corresponding to the sampling point Q6_02 located in Quebrada 6, It is understood that based on the value of the analyzed parameter it is inferred that the chemical composition of water is dominated by dissolved ions. That is, geochemical processes that control the quality and chemical composition of water (Malagón et al., 2021) . On the other hand, from the pH of the sample analyzed in the field for this chemical parameter, a maximum value of 8.6 has been obtained for the sampling point R1_02 corresponding to the one taken in River 1, and a minimum value of 7.8 for the sampling point ME-01 corresponding to the Embarcadero Spring. Based on the RCT of Cat 3-D1 and Cat 3-D2 the minimum value is within the permissible ranges while the maximum value is outside the permissible range for both cases.

For the parameter of total dissolved solids taken in the field, a maximum value of 889 ppm was found for the sampling point Q2_01 corresponding to Quebrada 2, and a minimum value of 258 ppm for sampling point Q6_02 corresponding to Quebrada 6. The values of dissolved solids must be controlled, since they can provide contents of some major elements and metals. The maximum value for this salinity parameter is 635 ppm for the sampling point Q2_01 corresponding to Quebrada 2, and a minimum value of 130 ppm for the sampling point Q6_02 taken in Quebrada 6, Salinity and conductivity are related because the amount of dissolved ions increase the values of both (Fernández et al., 2018) (Information Brochure, 2013) .Regarding the temperature sampled for this, a maximum value of 13.13º C was obtained for the sampling point ME-01 located in the Embarcadero Spring, and a minimum value of 6.10º C was found for the sampling point Q6_02 located in Quebrada 6.

CONCLUSIONS

The hydrogeological characterization of the study area shows that the first recharge system is produced by the slow infiltration of rain from the upper basin of River 1 and the other recharge system is produced by the infiltration and conduction of groundwater product of the Mantaro river basin, additionally underground flows from infiltration, product of rainfall and in the upper part of the microbasins, the aquifer discharge zone in the study area is Quebradas 2 and Rio 1 itself. Secondly, the results of climatological station A in which there is a minimum registered relative humidity of 65.7%, the average humidity recorded is 82.8% and the maximum relative humidity recorded is 92.8%, concluding that it has a seasonal behavior, in other words, the maximum rainfall occurs in the month of March and April, These are consistent with the total monthly rainfall, as it is an important process for the formation of rainfall and benefits the formation of rainfall in the region.

Third, the temperature results of the study area were recorded by Station A. The maximum temperature of 6.8º C. for the month of February and the minimum with a value of 2.6º C. for the month of August. The SENAMHI data agree with the theory of inverse proportionality of temperature and relative humidity and their high sensitivity to climate change. It has also been the calculation of the monthly potential evaporation by the method of Thornthwaite, whose results gave that the annual thermal index (I) = 10.3432, Exponent (a) = 0.67024 and annual ETP = 257.11, registering the greatest time of evapotranspiration in the month of December, not satisfying the

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demands of evapotranspiration, corresponding to the months of more precipitation because it is an area with little vegetation cover.

For the Inventory of groundwater sources, the electrical conductivity shows a maximum value of 2370 µs/cm corresponding to capacity BX-022, in addition to the minimum value of 528 µs/cm corresponding to capacity BX-010. Being the sample of the capacity BX-022 at 130 µS/cm below the ACE of Cat 3-D1 and 2630 µS/cm below the ACE of Cat 3-D2 it is noteworthy to consider that the level of electrical conductivity is natural in water and does not represent a problem in itself, on the other hand for the pH, a maximum value of 8.8 corresponding to capacity BX-007 and a minimum value of 7.46 corresponding to capacity BX-026 have been obtained, based on the ECA of Cat 3-D1 and Cat 3-D2, the sample of capacity BX-007 is 0.3 above the ECA of Cat 3-D1 and 0.4 above Cat 3-D2. The presence of alkaline substances, such as carbonates, can be highlighted and is demonstrable because the study area is located in Formation 2.

For the total of dissolved solids shows a maximum value of 1670 ppm in the capacity BX-022 and a minimum value of 370 ppm corresponding to the capacity BX-010, the data have a direct relationship with the electrical conductivity, because having a greater amount of dissolved solids in the water, the concentration of ions increases, therefore, the electrical conductivity will increase. The salinity is shown a maximum value of 1120 ppm in the capacity BX-022, and minimum value of 263 ppm corresponding to the capacity BX-010, it is understood that the relationship between electrical conductivity and salinity is directly proportional, because by increasing the concentration of dissolved salts the electrical conductivity will also increase, while temperature, a maximum value of 12.3 ° C corresponding to the capacity point BX-015 has been obtained, and a minimum value of 9°C corresponding to the capacity point BX-009, based on the ECA the temperature in the study unit is 10°C and the measurements made at the sampling points fall within the acceptable range of 3°C indicated in the ECA temperature parameter of Cat 3-D1 and Cat 3-D2.

It is concluded that there is a direct correlation between electrical conductivity, total dissolved solids and salinity, are indicators of chemical and physical quality of water in the study area. Since as the salt concentration dissolved in water increases, the electrical conductivity also tends to increase, due to the charged ions in the salts and their ability to conduct electric current through the water. However, in a situation of excess dissolved solids such as salts could be detrimental in the agricultural irrigation of areas surrounding the study area and drinking water supply. When comparing the EC with the ECA-based parameters of Cat 3-D1 and Cat 3-D2, the maximum sampling of electrical conductivity did not exceed the parameters established by the ECA of CE. Concluding at a natural electrical conductivity level, and not representing a problem in itself.

For the inventory of surface water sources for electrical conductivity in the field, there is a maximum value of 1276 µs / cm and a minimum value of 373 µs / cm referring that the chemical composition of the water is dominated by dissolved ions, on the other hand, the pH of the sample analyzed in the field, a maximum value of 8.6 and a minimum value of 7.8 has been obtained, implying that for ECA of the Cat 3-D1 and Cat 3-D2 maximum value is out of the permissible range for both cases. While the total dissolved solids has a maximum value of 889 ppm so the values of dissolved solids must be controlled, since they can provide contents of some major elements and metals, the maximum value of salinity is 635 ppm, salinity and conductivity are related because the amount of dissolved ions increase the values of both, finally the temperature was found a minimum value of 6.10º C.

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GRATITUDE

Thanks to the owner of the mining unit in central Peru for allowing a new analysis of the hydrological information and inventory of water sources in the study mine, thanks to the colleagues who supported us in the collection of the data, thanks to the National Service of Meteorology and Hydrology of Peru and to the National University of Moquegua for allowing to improve the theoretical bases to be able to substantiate the results of this research.

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