



Analysis of Various Properties of Mine Ground Water

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Abstract— Water plays a vital role in the mining industry, whereas access to clean water is not only a basic human right but also a valuable resource intertwined with cultural, economic, and environmental dimensions. This interdependence highlights the importance of ensuring water security and sustainable development when it comes to managing water resources, with a focus on the watershed level. The worldwide consequences of both current and abandoned mining activities on water systems are substantial, causing significant harm to the environment. Finding efficient methods to treat wastewater generated by mining is a major obstacle in the quest for responsible water resource management. Numerous technologies have been employed to treat mining wastewater, but the diversity of options complicates the comprehension of prominent research directions and technological advancements in this domain for policymakers and investors. This investigation employs bibliometric and social network analyses to investigate recent advancements in the treatment of water in the mining industry. The findings of this study pinpoint current areas of focus in scientific research and propose future research directions, emphasizing cost-effectiveness, high efficiency, energy conservation, time efficiency, and innovative treatment methods. The article primarily discusses the management of water and wastewater in the mining and mineral processing sector, with a specific focus on activities carried out on mining sites. It outlines the sources of wastewater typically produced in a mining operation and presents the distinct characteristics of wastewater originating from various sources. Following this, the article outlines potential strategies for reducing, treating, reusing, and disposing of wastewater generated by mining activities.

Keywords— Cultural, Economic, Reusing, Operations, Energy, Innovative and Environmental.

I. INTRODUCTION

Mining activities undoubtedly play a substantial role in the economic advancement of any nation. However, it's essential not to overlook the potential effects that these activities can have on local water resources and environments. According to (Chaudhari 2006) Open-pit mining has significant adverse effects on the environment, impacting various aspects such as soil, air, and water. These environmental concerns necessitate a thorough assessment of their conditions to fully understand the associated risks. Due to insufficient planning and regulatory oversights, substantial environmental degradation and damage to soil and water systems have become prevalent.

(Chen A. 2007) An investigation into well water quality was carried out in a rural area. This mining process involves the exposure of previously untouched earth materials, leading to the erosion of excavated soils, mineral ores, tailings, and fine materials from waste rock piles. Consequently, bodies of water and drainage systems are burdened with increased sediment loads. Additionally, the release of harmful substances through leaks or spills and the deposition of contaminated dust carried by the wind can lead to soil pollution, which may serve as the initial stage of water pollution.

(Bishnoi et. al 2008) A systematic Physico-Chemical analysis of the groundwater. Undoubtedly, the most profound consequence of mining activities is the profound impact on water quality and accessibility within the project vicinity. Central inquiries revolve around the continued suitability of surface and groundwater resources for human consumption and the ability of surface waters in the project area to sustain indigenous aquatic and terrestrial ecosystems.

Consequently, the execution of comprehensive studies concerning soil and water quality and their suitability for diverse applications is imperative. Neglecting this aspect could lead to catastrophic repercussions in the long term. (Singh 1997) carried out a series of studies concentrating on the Environmental Impact Assessment of Mining Projects. The results indicated that mining operations result in notable consequences, with a particular emphasis on water pollution. This pollution is caused by factors such as erosion, the introduction of oil and grease, and the pollution of water sources due to the discharge of mine water effluents.

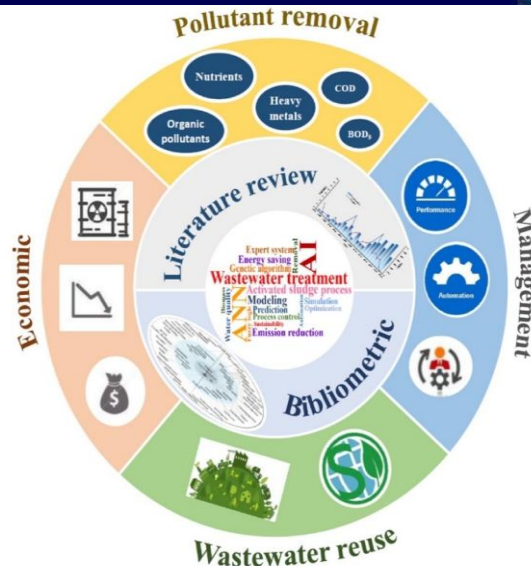


Fig. 1 Cycle of wastewater management

Major sources of water pollution in the mining industry encompass surface runoff, equipment cleaning, rainwater leaching minerals from mining sites, runoff from waste heaps, spoil heap failures leading to water mixing, and the issue of acid mine drainage. The situation worsens when wastewater from processing plants is discharged into water bodies, leading to significant contamination. This contamination elevates the levels of chloride, sulphide, and sulphate in the water. Apart from salts, heavy metals pose a significant threat, endangering aquatic life. (Moye J. et al.2017) This evaluation concerns the hydrogeological parameters, pH, Electrical conductivity, temperature and the groundwater level, and the geochemical assessment of Mg, Ca, Ti, Cr, Mn, Fe, Co, Ni, Zn, Cu, As, Se, Cd, Sb, Tl and Pb. Iron, Copper, Zinc, Mercury, Cadmium, Arsenic, and Lead are highly toxic pollutants that, if left unregulated, can result in fatalities among both animals and humans when consumed. (Mohan et al. 1996) indicate the water to free of heavy metal pollution.

polluted water has a detrimental impact on the flora and fauna reliant on water ecosystems. Therefore, it is crucial to conduct a comprehensive examination of water pollution indicators, as depicted in figure 1. Sukhija (1998) There is a general consensus that climate change is an ongoing phenomenon. This will inevitably bring about numerous environmental problems, including alterations to the hydrological cycle, which is already heavily influenced by anthropogenic activity. Moreover, gaining insights into how a specific pollutant is linked to the type of ore being mined can enhance our understanding of the repercussions associated with mining different minerals. Recognizing the connection between metal contamination or pollutants and the types of minerals can assist in predicting pollution patterns, ultimately enabling the evaluation of potential.

The mining industry has a profound impact on water resources, causing widespread concern due to water pollution issues globally. Water bodies surrounding mining sites are particularly vulnerable to contamination, posing significant threats. As per (Backman B et. Al 1997) the surface water hydrochemistry was investigated at various locations to determine the hydrochemical and heavy metals characteristics. Prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

II. ANALYSIS AND CLASSIFICATION OF MINE WATER

The primary source of water in mining activities is typically rainfall, while other sources include:

- Water intersecting the water table during mining
- Seepage water
- Proximity to major water bodies near the mining area
- Nearby mine workings, whether surface or underground
- Persistent heavy rainfall

Mine water serves as both a valuable resource and a form of industrial wastewater. Its management is critical, presenting challenges within mining areas but also offering a solution to local water scarcity issues. Throughout the mining process, surface water (SW) and groundwater (GW) considerations are integral. As per the study carried out by Khan R. (2005) Opencast lignite mines, pit-head thermal power plants, and other associated industries in the Neyveli mining and industrial complex generate huge quantities of solid and liquid wastes that are contaminated with heavy metals. Some of these are toxic or carcinogenic at sufficient concentrations. Copper, Zn, Mn, Fe, Ni, Cd, Cr, Co, Pb, and Hg concentrations in surface water in the study area are from 2 to 1200 times higher than average concentrations in river water worldwide.



Various aspects of water management, such as data collection, runoff control, water quantity assessment, diversion of water within mines, erosion and sediment control, dewatering, and addressing different forms of water pollution, are essential. Given the complex and extensive relationship between water and mining, practical solutions are necessary to ensure efficient mining operations while safeguarding the environment.

Mine water, an integral byproduct of mining activities, stems from various sources, with mining and ore processing contributing significantly. Open-pit mining is associated with the generation of wastewater during the production process, and after rainfall, it releases acidic water from waste rock piles. On the other hand, mine wastewater mainly consists of groundwater that has been contaminated during the mining process. Additionally, mineral processing produces wastewater through operations such as washing, crushing, and mineral extraction. This wastewater often contains ore particles, metals, or mineral processing chemicals, leading to significant pollution. These wastewater accumulations are stored in dams. Additionally, miscellaneous mine wastewater originates from vehicle washing, medical facilities, and domestic sources, carrying pollutant such as solids, oil, and organic matter.

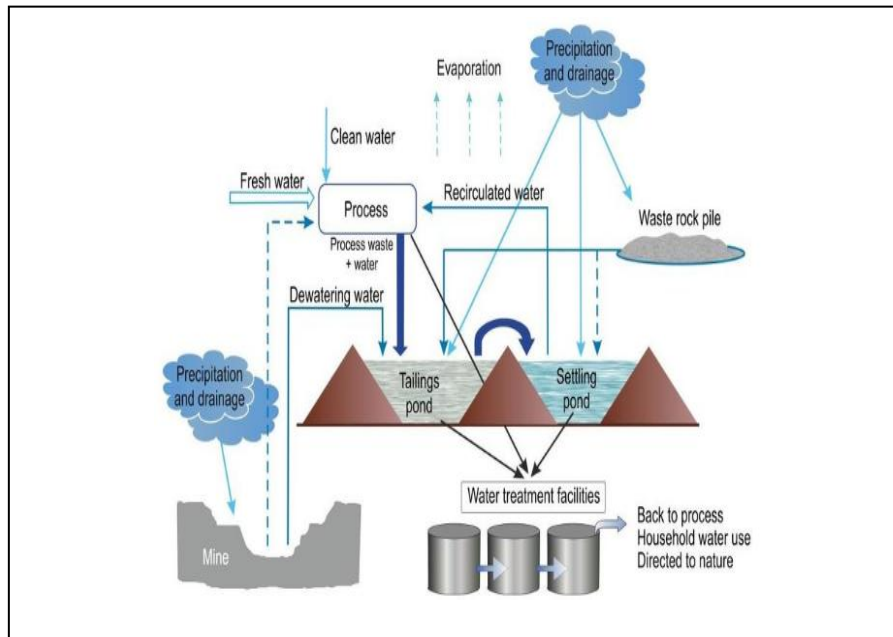


Fig. 2 Various source of mine water

The classification of mine water adheres to certain principles, including cleanliness, diversion, classification, treatment, quality, and reuse as shown in the figure 2. It encompasses three main categories: dewatering water, goaf water, and underground mine sewage.

Dewatering water in coal mines emerges from subterranean formations during coal extraction. In cases where a goaf forms due to extended mining, preventive measures are essential to prevent water accumulation, as unchecked accumulation can lead to hazards and jeopardize safety. In the realm of underground coal mining, mine sewage emerges as a result of the natural drainage of coal-based aquifers, which collect at the bottom of the well to form what is known as mine water. The pollution attributes of this mine water vary depending on the type of coal, leading to distinct classifications: there is clean mine water, mine water containing suspended solids, acidic mine water contaminated with acid, high-salinity mine water, and mine water containing specific pollutants.

- Clean mine water, of superior quality, maintains a neutral pH, low turbidity, and minimal harmful ions. It can be collected, pumped to the surface, and utilized as drinking or even mineral water after simple disinfection.
- Mine water with suspended solids is commonplace, characterized by neutral pH, moderate hardness, and the presence of small-sized coal and rock particles.
- High salinity mine water contains salt levels exceeding 1000 mg/L, originating from interactions with carbonate rock and sulfate layers. It leads to increased hardness and salt content in discharged water, impacting ecosystems and agriculture.
- Acid mine water, with a pH below 6, forms when groundwater interacts with coal layers, oxidizing pyrite into sulfurous and sulfuric acids. It contains abundant SO_4^{2-} , Fe^{2+} , Fe^{3+} , and Mn^{2+} ions, which, if untreated, degrade water quality, harming aquatic life and corroding materials.



- Mine water containing special pollutants houses toxic substances like fluoride, heavy metals, and radioactive elements. Dealing with such pollution proves challenging, posing environmental risks and hindering mine water resource utilization.

III. RESULTS AND DISCUSSION

Tiwari & Dhar (1994) Hydrogeologically, the river basin has two distinct units fissured and porous formations. The extraction of minerals through mining often results in diverse environmental consequences, particularly concerning water resources. Eneji et al. (2012) Explored the changes in water quality parameters over space and time. Understanding these impacts involves comparing the current situation with the pre-mining condition, assessing whether the outcomes are positive, negative, or a combination of both. This evaluation typically spans the core mining zone, encompassing a 5 km radius (or specifically the active mining area), and the surrounding buffer zone extending 10 km outward.

In the context of open-pit mining, potential impacts may include:

- Reduction in the water table, known as drawdown.
- Degradation of water quality, leading to water pollution.

TABLE I. SHOWS THE PROPERTIES OF WATER SAMPLE COLLECTED FROM NEAR TO MINE AREA AT SAMPLE ZONE-1 FROM A DISTANCE 1 KM

S. No.	Water Quality Parameters	Observed Value	Requirement Acceptable Limit	Standard Permissible Limit
1	pH	7.45	6.5 to 8.5	No relaxation
2	Color (Hazen)	Less than 5	5	15
3	Hardness (mg/l)	1062.34	200	600
4	Chloride (mg/l)	789.31	250	1000
5	TDS (mg/l)	2519.23	500	2000
6	Calcium (mg/l)	261.62	75	200

A. Analysis of Water pH near to Mine Boundary

In this project the research work is analysis based on the water sample collected near to the mine area a certain distance. The various Physico-Chemical properties of the water varies from place to place. Below the Table I shows the properties of water sample collected from near to mine area sample zone-1 from a distance 1km boundary of open pit. The table II shows the properties of water sample collected near to the mine at sample zone-2 at the radial distance of approx. 3 km. The table III shows the properties of water sample collected near to the mine at sample zone-3 at the radial distance of approx. 5 km. The pH scale is a measure used to specify the acidity or basicity of an aqueous solution. It ranges from 0 to 14, where a pH of 7 is considered neutral. Solutions with a pH less than 7 are acidic, while solutions with a pH greater than 7 are basic or alkaline. The pH value of a solution is determined by the concentration of hydrogen ions (H⁺) present in the solution. Mathematically, pH is defined as the negative logarithm (base 10) of the hydrogen ion concentration:

$$pH = - \log [H^+] \quad (1)$$

However, it's crucial to adhere to proper laboratory techniques and quality assurance practices to ensure the reliability and accuracy of the results obtained through this method.

$$(Cl^-) \text{ in (mg/l)} = \frac{(V_1 - V_2)}{V_3} \times N \times 35.45 \text{ (mg/l)} \quad (2)$$

Where,

V1 = volume in ml of silver nitrate used by the sample,

V2 = volume in ml of silver nitrate used in the blank titration

V3 = volume in ml of sample taken for titration

N = Normality of silver nitrate solution



TABLE II. SHOWS THE PROPERTIES OF WATER SAMPLE COLLECTED FROM NEAR TO MINE AREA AT SAMPLE ZONE-2 FROM A DISTANCE 3 KM

S. No.	Water Quality Parameters	Observed Value	Requirement Acceptable Limit	Standard Permissible Limit
1	pH	7.68	6.5 to 8.5	No relaxation
2	Color (Hazen)	Less than 5	5	15
3	Hardness (mg/l)	1074.33	200	600
4	Chloride (mg/l)	931.31	250	1000
5	TDS (mg/l)	2501.23	500	2000
6	Calcium (mg/l)	272.32	75	200

B. Analysis of Water Total Hardness (as CaCO₃)

Measuring the total hardness of water is crucial for evaluating its appropriateness for various applications, including drinking, industrial operations, and agricultural usage. Total hardness primarily depends on the presence of divalent metal ions like calcium and magnesium in the water. The standard method for monitoring involves complexometric titration utilizing a chelating agent such as ethylenediaminetetraacetic acid (EDTA), which forms stable complexes with these metal ions. Throughout titration, EDTA is incrementally introduced to the water sample until reaching the endpoint, which is signified by a color change facilitated by a suitable indicator. The amount of EDTA solution used in titration correlates with the concentration of metal ions, enabling the determination of total hardness.

TABLE III. SHOWS THE PROPERTIES OF WATER SAMPLE COLLECTED FROM NEAR TO MINE AREA AT SAMPLE ZONE-3 FROM A DISTANCE 5 KM

S. No.	Water Quality Parameters	Observed Value	Requirement Acceptable Limit	Standard Permissible Limit
1	pH	7.41	6.5 to 8.5	No relaxation
2	Color (Hazen)	Less than 5	5	15
3	Hardness (mg/l)	450.77	200	600
4	Chloride (mg/l)	215.34	250	1000
5	TDS (mg/l)	1030.43	500	2000
6	Calcium (mg/l)	126.12	75	200

In the procedure for determining total hardness in water samples, either a 25 mL or 50 mL well-mixed sample is first transferred into a porcelain dish or conical flask. Following this, 1-2 mL of buffer solution is introduced, followed by the addition of 1 mL of inhibitor. Next, a small quantity of Eriochrome black T indicator is added to the mixture. The sample is then titrated with standard EDTA solution (0.01M) until the wine-red color transitions to blue, marking the endpoint of the titration, and the volume of EDTA used (A) is recorded. To ensure accuracy, a reagent blank is run simultaneously to determine the volume of EDTA used (B). The volume of EDTA required by the sample (C) is then calculated as the difference between A and B. Finally, the total hardness of the water sample is determined by multiplying C by the appropriate conversion factor, considering the volume of the sample used.

The total hardness expressed as CaCO₃ in milligrams per liter (mg/L) is determined using the formula:

$$\text{Total hardness as } = [1000(V_1 - V_2)/V_3] \times \text{CF (CaCO}_3\text{), mg/l}$$

where

V₁ = volume in ml of the EDTA standard solution used in the titration for the sample,

V₂ = volume in ml of the EDTA solution used in the titration for blank,



V_3 = volume in ml of the sample taken for the test,
 $CF = X_1/X_2$ = correction factor for standardization of EDTA,
 X_1 = volume in ml of standard calcium solution taken for standardization, and
 X_2 = volume of ml of EDTA solution used in the titration.

TABLE IV. CONCENTRATION OF TOTAL HARDNESS (AS $CaCO_3$) IN WATER IN MARCH & APRIL 2023 AT DIFFERENT PORTION OF MINE SITE

S. No.	Point of Sample Collection	Observed Value (mg/l)	Requirement (Permissible Limits)
1	Project Site Water Tank	287.27	600
2	Colony Tank	345.45	600
3	RO Water	90.41	600
4	Raw Water Tank	323.64	600
5	Near Mines Water	454.55	600
6	Near Dispensary	481.82	600

TABLE V. CONCENTRATION OF TOTAL HARDNESS (AS $CaCO_3$) IN WATER IN JUNE 2023 AT DIFFERENT PORTION OF MINE SITE

S. No.	Point of Sample Collection	Observed Value (mg/l)	Requirement (Permissible Limits)
1	Project Site Water Tank	306	600
2	Colony Tank	306	600
3	RO Water	96	600
4	Raw Water Tank	235	600
5	Near Mines Water	418	600
6	Near Dispensary	214	600

TABLE VI. CONCENTRATION OF TOTAL HARDNESS (AS $CaCO_3$) IN WATER IN JULY & AUGUST 2023 AT DIFFERENT PORTION OF MINE SITE

S. No.	Point of Sample Collection	Observed Value (mg/l)	Requirement (Permissible Limits)
1	Project Site Water Tank	275	600
2	Colony Tank	316	600
3	RO Water	90	600
4	Raw Water Tank	187	600
5	Near Mines Water	362	600
6	Near Dispensary	370	600

Table IV, V and VI present the physicochemical characteristics of surface water collected from three different areas in proximity to open-pit mines. These tables offer an overview of the general patterns observed in certain physicochemical attributes of the water within the mine pit.

The data indicate that the average pH levels in sample zone 3 (beyond 5 kilometers), and sample zone 2 (beyond 3 kilometers) were within an acceptable range, approximately around 7, while in sample zone 1 (within 1 kilometer), the pH was slightly



alkaline, falling between 7.3 to 8.1 on the pH scale. The coloration of the water in all three zones was consistent and registered values below 5.

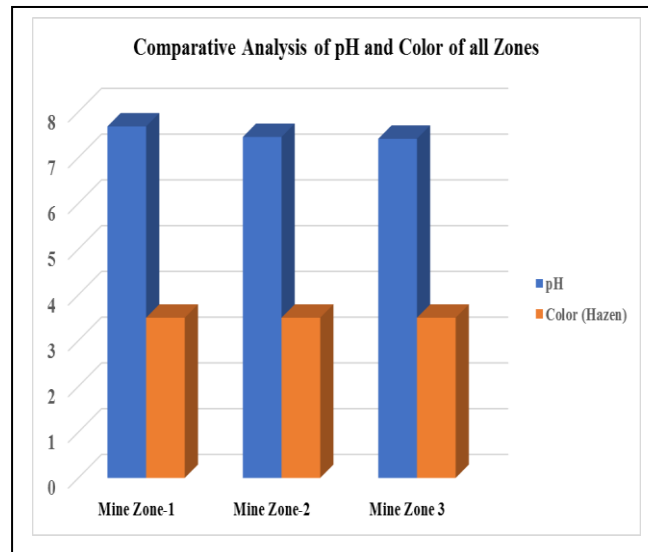


Fig. 3 Comparative analysis of pH and color of all zones

Mangukiya et al. (2012) re-confirmed that Groundwater is a natural resource for drinking water. Regarding properties like water hardness, chloride levels, total dissolved solids (TDS), and calcium content, it is noteworthy that in sample zones 1 and 2, these values were notably higher compared to zone 3 as shown in the figure 3 & figure 4. Furthermore, in some instances, they exceeded the permissible limits as per established standards.

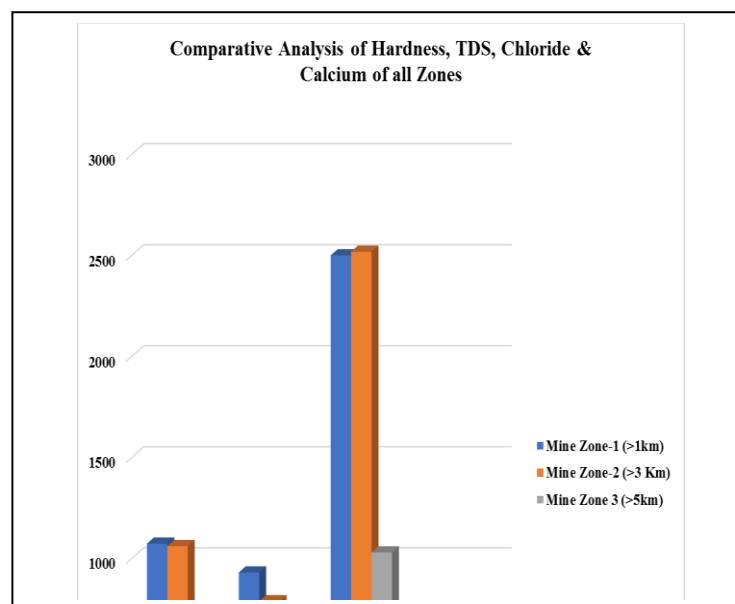


Fig. 4 Comparative analysis of hardness, tds, chloride & calcium of all zones

Based on the tables IV to VI a comparative analysis of the concentration of chloride at mine site can be understood at different conditions of atmosphere and temperature. This comparative analysis can be understood from the figure 5.

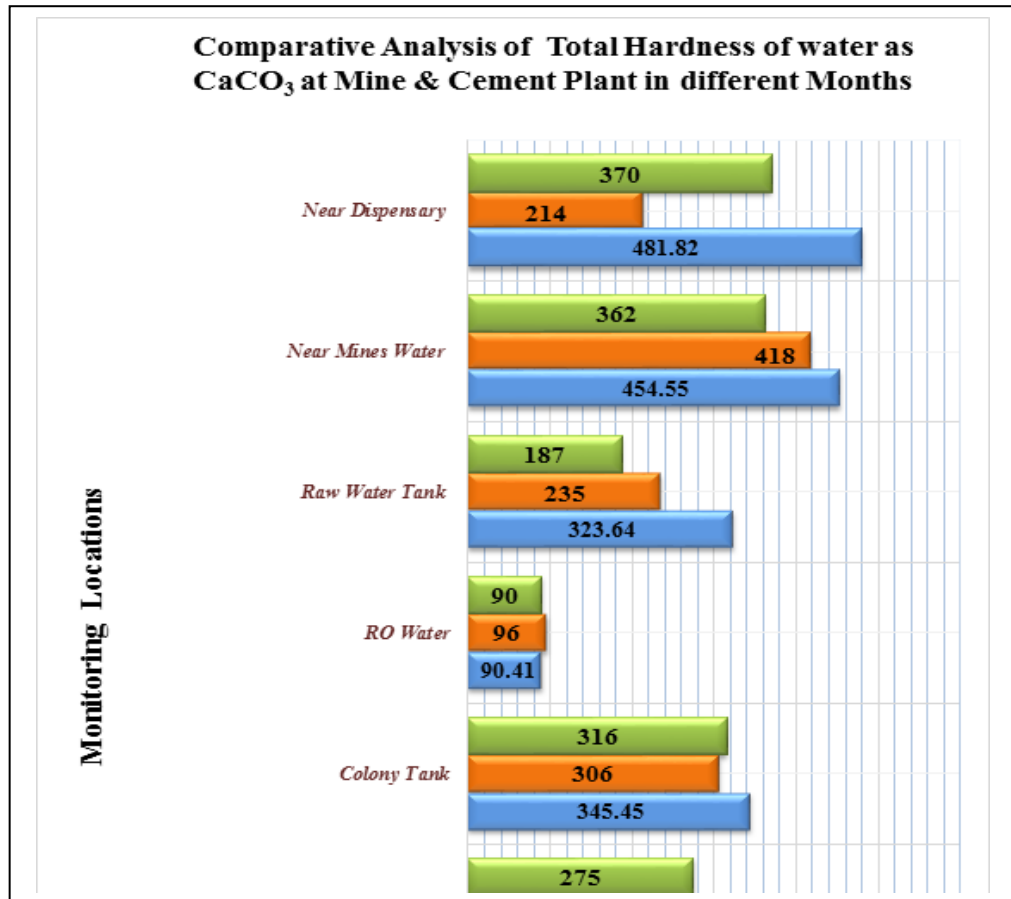


Fig. 5 Comparative analysis of total hardness of water as CaCO₃ at mine site in different months

As per the figure no. 5 it is clearly found that the concentration of total hardness of water as CaCO₃ (mg/l) at various locations are comparatively higher in the month of March & April from June to August. That's mean due to heavy rain in the monsoon season the total hardness of water as CaCO₃ (mg/l) of water level get quite low compare to summer season (March & April).

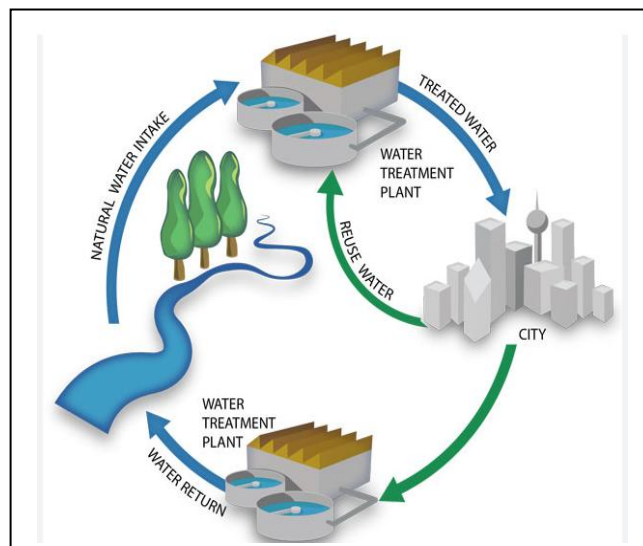


Fig. 6 Reutilization of Waste water from Working Industry



IV. CONCLUSION

Hem, J.D. (1970) The quarry pits should be reclaimed and rehabilitate after mining

The present study highlights techniques to identify suitability of water for different purposes such as domestic, irrigation and industrial uses. As per the water quality assessment of all the six qualities gave encouraging results and also suggest for the different approach for the reutilization of mine water as shown in the figure 6.

To enhance both environmental parameters and overall productivity in mining operations implementing water management practices such as recycling and treatment systems, Community engagements and communications can minimize water consumption and prevent contamination of water bodies.

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