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Assessment of Impact of Cement Industry on Surface and Ground Water Quality

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Abstract: *This study aims to assess the impact of the cement industry on surface and groundwater quality. The research focuses on a specific cement plant location Athwajan Srinagar J&K and evaluates the physico-chemical parameters of water samples collected from various points around the plant. Parameters such as pH, temperature, turbidity, dissolved oxygen, total dissolved solids, hardness, calcium, alkalinity, sulphate, nitrate, fluoride, chloride, and iron are analyzed to determine the extent of pollution.*

The study employs a combination of field surveys, laboratory analysis, and statistical methods to compare water quality between areas affected by cement industry emissions and control sites. The findings will highlight the adverse effects of cement industry activities on surface and groundwater quality, including potential health risks for local communities and ecological impacts.

The objective is to provide a comprehensive understanding of the environmental implications of cement production and to identify strategies for mitigating these impacts. This research will contribute to the development of sustainable practices in the cement industry and inform policy decisions aimed at protecting water resources and public health.

I. INTRODUCTION

A. General

All life on Earth depends on water, an essential natural resource. Water is the essence of life. It is important in many areas, such as the industrial, economic, sociological, and environmental sectors. Globally, the availability, quality, and management of water resources have become urgent issues that call for in-depth study and creative solutions. Growing urbanization, industrialization, climate change, and population growth have all made the problems related to water worse in recent years. Water scarcity, pollution, poor access to clean water, and the deterioration of aquatic ecosystems are examples of serious concerns that require quick response times and efficient management techniques.

Surface water, which includes rivers, lakes, reservoirs, ponds, and streams, represents the major component in the Earth's hydrological cycle and provides a unique source for numerous ecological, social, and economic functions. Ranging from drinking water for humans and irrigation to aquatic ecosystems and transportation and recreation, surface water resources should be recognized and taken into account to ensure that they are managed effectively. Regulating regional climate and aiding terrestrial ecosystems surface over lie a fundamental role in the impact of surface water. Precipitation, natural water inflow, and evaporation control the distribution and flow of surface water over the land and are recharged and removed from the atmospheres surface waters. Pollution from cities and industries is one of the main reasons that fresh surface water is becoming less accessible for these uses worldwide. Because rivers are so easily accessible for the disposal of waste, they are particularly vulnerable to industrial pollution, making them extremely vulnerable. According to Bai, Zhang, Sun, Wang, and Zhu (2006) and Pandey et al. (2005), a sizable portion of global pollution is caused by industries.

B. Surface Water's Significance

The importance of surface water may be seen in its critical role in maintaining many ecosystems and life. It provides home, agricultural, industrial, and recreational needs while acting as the world's main supply of drinking water for human communities. Surface water bodies are home to a diverse range of aquatic life, including fish, amphibians, crustaceans, and plants. In addition to facilitating ecological processes like nitrogen cycling, sediment transport, and flood control, they also support genetic variety and offer homes and breeding grounds for species. The availability of surface water resources also supports commercial ventures that propel national and international economies, including tourism, transportation, fishing, and hydro-power production.

Groundwater is an essential resource for many uses, such as the supply of drinking water, irrigation of agricultural land, industrial operations, and ecological support. Particularly in dry and semi-arid locations with limited surface water, groundwater serves as the

primary or only source of freshwater in many parts of the world. Municipal water supply is one of the main applications of groundwater. Groundwater is extracted from aquifers by well drilling, and before it is supplied to residences and commercial buildings, it is treated to meet drinking water regulations. Furthermore, groundwater is essential for irrigation since it gives crops water, which is particularly useful during dry spells or in areas without consistent surface water supplies. The formation of dry and semi-arid zones depends heavily on ground water. Compared to surface water, it is thought to be significantly cleaner and pollution-free. However, continuing to release solid waste, sewage, and industrial effluents into the ground water pollutes it and poses health risks (Raje et al., 2002).

C. Ground Water's Significance

Groundwater, which is frequently underground and unseen, is essential to the survival of ecosystems and life on Earth. Its relevance goes well beyond its apparent subtlety; it affects many facets of human endeavors, ecological balance, and environmental stability. It is impossible to overestimate the significance of groundwater, which is used to support agriculture and is also an essential supply of drinking water. Being the principal source of drinking water for billions of people globally is one of the main significances of groundwater. Groundwater is essential to populations in many places, particularly in arid and semi-arid regions, as it offers a steady and dependable source of water even during dry spells or shortages. It is a popular source of drinking water in due to its accessibility and quite good quality. In many regions of the world, its accessibility and generally good quality make it a preferred source of drinking water. Additionally, groundwater is essential to agriculture, which is the main source of food production worldwide. Water that percolates through rock and dirt and builds up in underground aquifers is referred to as groundwater. The water bodies that are visible on the surface of the Earth, however, are known as surface water and include rivers, lakes, and streams. Both sources are vital to many human endeavors, including drinking, farming, and industrial operations. However, there is a serious risk of contamination to these water sources, especially from sectors like cement industry. Since they provide the building blocks for roads, bridges, and buildings, the cement industry is crucial to the development of infrastructure. However, a variety of chemical reactions and raw materials are used in the production process, which could pose environmental risks. The pollution of surface and groundwater resulting from cement production is one of the main issues. Cement industries frequently contaminate groundwater through a number of different processes. Primarily, the extraction of raw materials like clay and limestone can upset the hydro geological equilibrium, changing the course of groundwater flow and depleting aquifers. The depletion of freshwater aquifers could result in the infiltration of saline water, making them unfit for human or agricultural use. In addition, a lot of water is needed during the manufacturing process to clean and cool machines. Many contaminants, including organic compounds, suspended particles, and heavy metals, are frequently found in the wastewater produced by these procedures. This effluent poses threats to the environment and public health if it is not sufficiently treated and seeps into groundwater, toxicity aquifers. Since 1982, India has played a significant role in the global cement industry, coming in second place globally in terms of cement production and contributing significantly to the national economy. The industry's potential for building development and infrastructure has attracted significant investments from both domestic and foreign businesses. Recent initiatives like smart cities are expected to significantly enhance the cement sector, with foreign companies playing a major part in government-driven projects [1]. The demand for cement is mostly driven by the housing and real estate sectors, which account for over 65% of India's total consumption. Moreover, the existence of public infrastructure and the growth of industry have an impact on cement consumption. An Environmental Impact Assessment (EIA) is an essential procedure in the cement business in India. It entails a thorough examination of the environmental and social consequences throughout the cement manufacturing life cycle.

Data collection on current environmental conditions, identification and evaluation potential environmental and social impacts at various stages of the cement production assessment of noise and vibration levels, assessment of mining activities, assessment of solid and hazardous waste generation, analysis of energy consumption patterns, and estimation of greenhouse gas emissions are all included in this assessment [2]. In many nations, including India, the EIA process is mandated by law and calls for cooperation between the project's backer, environmental specialists, government agencies, and impacted people.

D. Cement Industry

The cement industry plays a vital role in constructing national infrastructure due to its increasing share of global output. In order to accommodate its rapid expansion, the company moved its cement production facilities to countries with laxer environmental regulations in response to growing environmental concerns in developing nations, especially in Europe [4]. Concrete is a composite material composed of sand, gravel, shattered stones, and cement that is often created via cement manufacturing. Cement plays a fundamental role in both the social and economic spheres and is essential to the development and enhancement of infrastructure.

With 5–6% of the carbon dioxide emissions produced by human activity coming from it, it contributes significantly to global warming. Furthermore, it disperses hazardous metals, microscopic particles, and persistent chemical pollutants like dioxins. A vital part of modern-day construction is the cement industry, which is responsible for creating infrastructure like buildings, bridges, roads, and dams. It entails the manufacturing of a crucial component of concrete; the most frequently used building material in the world. The process of making cement is complex and comprises several steps, from the extraction of raw materials to the finished product. Fundamentally, cement is a fine powder composed mainly of clay, limestone, and additional ingredients such as gypsum, sand, and iron ore. To get to cement factories, these basic materials must be mined or quarried from natural reserves. Large chunks of limestone and other minerals are blast-blasted or extracted from the earth's crust as the first phase in the cement-making process. In order to create raw meal, the raw materials must first go through a number of crushing, grinding, and mixing steps. For the purpose of producing clinker, this uncooked meal is then burned to high temperatures in a kiln, usually around 1450°C (2642°F). Cement is made from clinker, a nodular material that is pulverized into a fine powder after coming out of the kiln. As a result of the high heat required to turn raw materials into clinker, the cement manufacturing process is energy-intensive. Because carbon dioxide (CO₂) is generated during the calcinations process, the industry contributes significantly to greenhouse gas emissions. The cement industry is a worldwide enterprise, with prominent manufacturers situated in areas with an abundant supply of raw materials and easy access to transportation infrastructure. Cement is produced in vast quantities worldwide, with China, India, and the United States producing a lion's share of it. But the sector is also dispersed, with many smaller manufacturers functioning in various regions of the globe. Emissions are being reduced, though, with the use of more energy-efficient devices and alternative fuels like biomass and fuels sourced from waste. Considering its significance to contemporary civilization, the cement business faces a number of difficulties, such as demand swings, regulatory demands, and environmental concerns. Cement producers are taking more and more seriously environmental concerns such as habitat damage, depletion of natural resources, and pollution of the air and water. Furthermore, industry innovation and investment in cleaner technologies are being propelled by government initiatives that aim to promote sustainable practices and reduce emissions.

E. Water Quality Index

WQI is a numerical expression that reflects the general quality of water by combining different physical, chemical, and biological parameters. It gives a clear and easy way to evaluate and convey the general state of water resources to the public, policymakers, and other stakeholders. Thus, to compute a Water Quality Index, water quality data is gathered from different sampling points within a body of water, such as rivers, lakes, or groundwater sources. This information usually consists of data on such factors as pH, dissolved oxygen, biochemical oxygen demand (BOD), turbidity, nutrients (for example, nitrogen and phosphorus), heavy metals, and fecal coliform bacteria. Each parameter is given a weight or a importance factor according to the significance of water quality and its effect on human health and the environment. These weights are usually set by the experts or through the analysis of the statistics. Following the weights assignment, each parameter's value is normalized and the sub-index is created from it using a predetermined scale or function. These sub-indices are then totaled to give the Water Quality Index score for the water body. The last index score which is typically between 0 to 100 or 0 to 10, the higher the score, the better the water quality is. The Water Quality Index scores can be grouped into the different quality classes like excellent, good, fair, poor, or very poor and thus, the water quality conditions can be interpreted clearly. The application of a Water Quality Index makes the comparison of water quality at different places and at different periods of time easy. It is a tool that enables one to discover the patterns, rank management actions, and the communication of water quality information to the public and decision makers in the most efficient way. WQI is a good technique for evaluating the water appropriateness for different useful purposes [1]. It gives a comprehensive description of the water quality as a result of the analysis of different water quality parameters [3]. The WQI is a tool which enables the researchers to comprehend the composite effect of the different water quality parameters on the overall water quality [3]. With the help of WQI, it is possible to evaluate the water quality for different uses, for example, drinking, irrigation, or industrial use [2]. The use of WQI is the reason why the water management and treatment strategies are made based on the water quality indirectly, then it helps the people to make those decisions [2]. WQI is the gauge of the technical conditions of water which can be easily explained by water quality data by using the numerical value, thus, the comparisons can be made and the monitoring is done over time. WQI is the main factor of water resource management, hence it enables the sustainable use of water for various beneficial purposes, by giving a complete analysis of water quality.

F. Scope of Work

An essential component of the development of global infrastructure is the cement sector; however, it also presents serious environmental problems, especially with regard to water quality. The manufacture of cement entails a number of activities that have the potential to contaminate water by releasing pollutants such as chemical additives, suspended particles, and heavy metals. For sustainable development and efficient environmental management, it is crucial to comprehend how the cement industry affects the quality of water. This scope of work aims to provide an overview of the steps involved in carrying out an evaluation of the environmental effects of the cement industry on the quality of water. In order to protect water resources impacted by cement manufacturing operations, the evaluation seeks to identify possible sources of contamination, assess the level of pollution.

II. LITERATURE REVIEW

A. General

Many papers are written on industrial pollution and water, but this is the first that studies the impact of cement industry on both surface and ground water resources. Many papers and findings are listed and discussed below.

B. Reviews

- 1) Mbaka, Dr. John Gichimu (2023). The study evaluates how the cement industry significantly affects the quality of the water in the Athi River in Kenya. It finds that several physicochemical variables surpass WHO guidelines, which calls for the implementation of pollution control measures. Water samples were collected from three sites along the Athi River: one upstream, one near a cement industry, and one downstream. Samples were analyzed for physical and chemical characteristics using laboratory techniques and compared against WHO standards. Statistical analysis identified significant differences in water quality parameters among the sites.
- 2) T. A. Aga1, C. C. Mbajorgu, C. C. Anyadike, and V. Ogwo 2020. The study evaluates the effect of turbidity, low DO levels, and excessive TSS on the water quality of the Ngo River in Benue, Nigeria, which impacts aquatic life and usability. Sampling: Water samples were collected from 7 points along a 15 km stretch using GPS.- Collection: Samples were taken at 20 cm depth in pre-washed bottles. In-Situ Measurements: Parameters like temperature, pH, and DO were measured on-site. Laboratory Analysis: Other parameters were analyzed in a lab after transport in an ice chamber. Statistical Analysis: t-tests compared upstream and downstream results to confirm the effluent's impact.
- 3) AKBAR ZIA UDDIN 2011, N.A.SIDDIQUI, R.N.SHUKLA. The study examined how the cement industry affected the quality of the ground water close to the facility, emphasizing the necessity of treating water before drinking and adhering to WHO recommendations. Groundwater Sampling: Samples were collected from four locations around the cement plant. Seasonal Sampling: Samples were taken in each season over 5-6 years. Chemical Analysis: 19 parameters were analyzed to assess groundwater quality. Comparison with Standards: Results were compared to BIS and WHO drinking water standards. Data Presentation: Findings were organized in tables showing average results. Historical Comparison: Current results were compared with previous studies to identify trends.
- 4) Imtiyaz Ali, Beenu Raj, Shree Ganesh, Jamshed Zaidi, Abhimanyu Singh, and Swati Gupta. 2013. Groundwater quality measures were found to be within allowable bounds in the study on the diamond cement industry in Jhansi, suggesting that the cement company's activities have had little effect on the quality of the water.
- 5) G.M. Obaje & A.R. Ipeaiyeda 2017. The study examines the physio-chemical properties of cement effluent and how they affect the Onyi River's water quality in Obajana, Nigeria. The study assesses the impact of cement plant effluent on the Onyi River in Nigeria, focusing on its effects on water quality, aquatic ecosystems, and community health. Sample Collection: Upstream and downstream water samples. Physico-Chemical Analysis: Parameters like pH, turbidity, and heavy metals. Statistical Analysis: To determine significance and correlations. Comparative Studies: Against established water quality standards.
- 6) Abdullateef Abdullahi Ibrahim, Muhammad Abdullahi Ibrahim, Ali Gambo Yusuf. Studies implications of industrial effluents on surface water and ground water. Industrial discharge contaminates surface and groundwater, affecting their use for drinking, bathing, and agriculture. This pollution harms crops, aquatic life, and alters water quality. The paper reviews contamination causes and identifies industrial discharge contaminants, highlighting the significant environmental threat.
- 7) Ronggang Zhang, Ching-Cheng Lu et al. The paper "Dynamic Environmental Efficiency Assessment of Industrial Water Pollution" in China highlights Severe Water Pollution: Prompting regional investments in water management. Variability in Management: Effectiveness varies by region due to environmental, economic, and technological factors. Efficiency Balance: Balancing wastewater treatment with reduced discharge is crucial. Methodology: Dynamic SBM model evaluates wastewater resources across 30 regions. Findings: Regions with high industrial output don't always show improved wastewater treatment

- efficiency, with significant variability in efficiency scores.
- 8) Rayees Ibrahim Lone, S Subramani. It highlights the cement plant's emission of pollutants like CO, NO_x, SO_x, dust, smoke, and noise, which significantly pollute local water bodies and pose severe health risks to residents. The study analyzes the correlation between these pollutants and their adverse effects on water resources and human health, emphasizing the environmental and health challenges posed by the cement industry in Kashmir.
 - 9) Mohd Yazid Bajuri. Cement dust alters soil properties, degrades air quality, reduces microbial populations in soil and leaves, and shows seasonal variability. The research involved collecting soil, air, and water samples near cement factories and comparing them to control sites to assess pollutant levels and environmental effects. Samples were analyzed for parameters like metal content, TDS, pH levels, and microbial populations to understand the impact on soil and water quality. Statistical methods were used to interpret the data and determine significant differences between polluted and unpolluted areas. The study evaluated the health effects of cement dust pollution on human health through health data reviews or community surveys.
 - 10) Javad Dawoudian, Sadegh Bahamin, Henry Bikwibili Tantoh. Using a mathematical matrix, it found that the effect of the cement factory on the environment produced four categories of significant effects: L, low; M, medium; H, high; and VH, very high. Results in terms of basic criteria revealed 0.70 of the most destructive effect was related to water pollution.
 - 11) Kayalvizhi, J. S. Amarnath, B. Sivasankari. In this article, the negative externalities on land, water and crops especially in the form of yield decline, decline in water quality and land quality, averting or defensive expenditure for land and water and International Journal of Current Microbiology. Researchers assessed land, water quality, and crop health near cement factories in the Ariyalur district and collected data on crop yields to quantify the impact of pollution. Water quality tests measured parameters like pH, turbidity, and harmful chemicals to evaluate the degradation of water quality. The study calculated the economic costs of defensive expenditures to mitigate pollution effects.
 - 12) Simerjit Kaur, Promila Malik Impact of Industrial Development on Groundwater & Surface Water Quality in Industry Dominating Sectors of Chandigarh, India, The study in Chandigarh, India, analyzed surface and groundwater pollution from industrial effluents in November 2011, focusing on parameters like pH, alkalinity, calcium, magnesium, hardness, DO, and COD. The water had low pH and high alkalinity, making it unpalatable and hard. Calcium and magnesium levels were excessive, and low DO indicated industrial oxygen consumption. COD levels suggested pollution. Proper treatment of waste before disposal is recommended to prevent further pollution, as the water is not fit for human consumption without treatment. Significant variations were observed between groundwater and surface water parameters.
 - 13) J. Cowie, F. P. Glasser. The reaction between cement and natural waters containing dissolved carbon dioxide, Chemical Equilibrium Modeling: Used MINEQL to model chemical equilibria involving CaCO₃, CO₂, and H₂O to assess the effects of CO₂ on cement. Aggressivity Index Calculation: Developed an aggressivity index to quantify groundwater's ability to dissolve cement based on Ca(OH)₂ leaching and CaCO₃ precipitation. Diffusion Modeling: Applied Fick's law to predict ion and molecule movement through the cement-water interface and calcium carbonate precipitation. Thermodynamic Calculations: Performed calculations to determine free energies of formation for involved species, ensuring stability and reactivity understanding. Experimental Validation: Referenced empirical observations and previous studies to validate the proposed models and findings.
 - 14) Sudheer Kumar Shukla, Ajay Singh Nagpure et al. Discuss assessment of environmental profile in the vicinity of Indian cement industry, The researchers conducted a socio-economic study in eight villages near the Jaypee Rewa Cement plant using interviews, group discussions, and questionnaires to gather data on demographics, crop production, and basic amenities. The study included water quality assessment using AWWA and APHA methods, impact assessment on local vegetation, dust load estimation on plants, and measurement of chlorosis and necrosis. Demographic data and availability of basic amenities like schools and health centers were also assessed.
 - 15) A. K. Kadam & M. Ramakrishna Reddy et al., did Groundwater quality assessment using multivariate statistical approach and geospatial modelling around cement industrial corridor, South India. Groundwater samples were collected from 40 bore wells in 20 villages around Yerraguntla Mandal, Y.S.R Kadapa district, Andhra Pradesh, during the PRM season of 2019 and POM season of 2018. Sampling locations were recorded using a portable GPS device. Samples were collected in pre-cleaned and dried polyethylene bottles and carried to the laboratory. pH, electrical conductivity, and total dissolved solids were measured using respective meters. Total hardness and major cations (calcium, magnesium) were determined by titrimetry, while Na⁺ and K⁺ were measured using a flame photometer. Major anions (carbonates, bicarbonates, chlorides) were analyzed by titrimetry; sulfates and nitrates by spectrophotometric methods. Fluoride was determined using an ion selective electrode with TISAB III buffer.

- 16) M. S. A. AL-Taay, A. H. A. Al-Assie, R. O. Rasheed, The study assessed the environmental impact of the Bazian cement factory in Sulaimani from September 2015 to August 2016. Cement dust emissions were found to affect biodiversity and the quality of water, soil, and ecosystems, impacting plant photosynthesis and growth. Water, soil, air, and plant samples (*Platycladus orientalis*, *Eucalyptus* spp., *Melia azedarach*) were collected. Water samples from 10 sources were analyzed for physicochemical characteristics and heavy metals. Soil samples from 12 sites were analyzed similarly. Air gas results and dust from the main stack were also analyzed monthly.
- 17) Umesh Chandra Mishra, Surendra Sarsaiya & Amita Gupta, aimed to provide a systematic analysis of the global cement industry, covering generation, pollution, ecosystem impact, technological improvements, sustainable models, laws, challenges, and future directions. India is the second-largest cement producer after China, with a significant portion of global production. Pollutants: Cement manufacturing emits NO_x, SO_x, CO, CO₂, H₂S, VOCs, dioxins, furans, and particulate matter. Quarrying, blasting, drilling, trucking, and other activities generate dust particles. Methods like the DEMATEL evaluation and AHP technique help prioritize climate alteration and mitigation options. Adopting sustainable techniques and alternative fuels can reduce CO₂ emissions by 12% by 2050. The review highlights the importance of sustainable practices in reducing industrial emissions and promoting more environmentally friendly cement production.

C. Inferences Drawn

The following references were drawn out after going through the above mentioned literatures:

- The location where study is conducted should be examined properly.
- The climate and Rainfall patterns are not properly utilized.
- There can be drastic time movement if proper equipment is used.
- There can be effective ways to reduce cement industry pollution.
- Consider longitudinal studies to observe changes over time.
- Geo-morphology and soil characteristics can improve the results of the study.
- Regional Geology and study of rocks should be undertaken.
- Topography of the land properly studied will help a lot.
- There can be drastic improvement by studying Drainage patterns.

D. Research Gaps

There are some research gaps which are very essential and they have a very good role in the research work.

- 1) No comprehensive study has been done in Srinagar to assess and evaluate the impact of cement industry on surface and ground water quality.
- 2) There can be significant improvement in the study of this field for future generations.
- 3) Existing research may be outdated and needs to be updated.
- 4) New ideas and concepts may not have been studied at all.
- 5) Paper not been peer reviewed by a journal.

III. RESEARCH METHODOLOGY

A. Problem Statement

“Assessment of Impact of Cement Industry on Surface and Ground Water Quality”

B. Objective of Study

Groundwater is the water that is held in aquifers beneath the surface of the Earth, whereas surface water is the water that is found in streams, rivers, and lakes. When it comes to drinking, irrigation, and environmental preservation, it is essential to understand the quality of both kinds of water. Samples of both surface and ground water be taken in Athwajan Srinagar, and areas surrounding it, in order to determine the characteristics and quality of the water resources in this area.

We usually utilize equipment, such as bottles to collect samples of surface water and ground water, for the purpose of capturing differences in water quality, these samples should be frequently taken at several locations along a river or stream. The quality of the surface water in the area determined by collecting samples from the Jhelum River, and Ponds. Whereas the ground water as well as potable water samples are collected from the available water resources around the mine site i.e. Hand pumps and Bore wells. Each sample is carefully labeled, stored, and brought to the laboratory for thorough examination.

The bottles that are used for testing are sealed and then carried to the laboratory. In a refrigeration unit, the samples are kept at 4°C in temperature.

Testing of all of the samples from the various locations using Horiba U52 water monitoring apparatus in the field and a standard procedure and UV-vis spectrophotometer in the lab.

C. Objectives of Research

- 1) To Assess current water quality, especially in areas surrounding cement producing plants. Identify the sources and pathways of water contamination associated with the produce of the cement.
- 2) To identify the levels of the main pollutants found in water bodies affected by the cement industry, such as suspended solids, heavy metals, and chemical additives.
- 3) To Examine thoroughly each of the collected water samples in search of important aspects including chemical, biological and physical indicators (These factors may include factors such as pH, turbidity, nitrates, sulphate, total dissolved solids (TDS), calcium, chloride etc.)
- 4) To Compare the surface water quality and the groundwater quality regulation standards that are drafted and issued by the relevant national and regional environmental agencies with the data on water quality.
- 5) To Find out the health and environmental risks due to water pollution from cement industry and to give recommendations for minimizing the adverse effects on the environment and suggest water quality controlling for the cement industry.

D. Testing of Samples

Type of sampling

The technique of grab sampling is the procedure of taking a singular sample at a particular location and time at a site.

The collection of samples is done quickly at a place which has been selected in advance, at a fixed depth and time.

Sampling Methods

Samples are manually taken from a variety of sampling locations using the technique outlined below for Surface Water: Samples are gathered from multiple sources.

Samples of drinking water and ground water taken from borewells and hand pumps in the study region.

In order to understand the quality of water, we need to conduct tests in a laboratory setting. This involves collecting small samples of water from different places, like rivers or lakes, and analyzing them for various things that can affect water quality. These tests look at things like how clear the water is, how much oxygen is dissolved in it, and if there are any harmful bacteria or chemicals present. By doing these tests, we can figure out if the water is safe for drinking, swimming, or supporting aquatic life. This information helps us make decisions about how to protect and improve our water resources for everyone's benefit.

The assessment of water quality is paramount for ensuring the health and sustainability of aquatic ecosystems as well as safeguarding public health. To achieve this, a comprehensive methodology for laboratory testing of water samples is indispensable. This methodology serves as a structured framework for collecting, analyzing, and interpreting various physical, chemical, and biological parameters present in water bodies. Through systematic testing, it enables the calculation of a Water Quality Index (WQI), a numerical expression that succinctly summarizes the overall condition of water resources. By employing this methodology, researchers, environmental scientists, and regulatory agencies can effectively evaluate water quality, identify potential pollutants, and prioritize management actions to mitigate adverse impacts. This introduction delineates the fundamental steps involved in laboratory testing, including sample collection, parameter selection, laboratory analysis techniques, data interpretation, and quality classification. Ultimately, this methodology serves as a cornerstone for informed decision-making and proactive measures aimed at preserving and enhancing water quality for present and future generations.

We should conduct the tests of the water in a laboratory where we can get the knowledge of the water quality. This means you should collect a few water samples from different places, like lakes or rivers and then test these samples for the presence of the pollutants which are harmful to the quality of the water. The samples collected are from both upstream and downstream, in order to examine any changes. These tests check the color of the water, the amount of oxygen in it, and the presence or absence of hazardous substances or germs. We can find out how the water is good for swimming, drinking, or preserving the aquatic life by doing these tests. Hence, the use of this knowledge enables us in a better way to protect and improve our water resources for the sake of all.

E. HoribaU52



Fig. 3.1. Horiba U52

The Horiba U52 is an intelligent addressing instrument that monitors in-depth water quality with high proficiency. Environmental experts, researchers or water treatment professionals are the most formidable clientele that find it useful. U-52 is synonymously known for adaptability, durability and simplicity among many other field applications in the Horiba's U-50 series. Consequently, this multi-parameter water quality meter has a number of parameters to measure among which includes pH, ORP (oxidation-reduction potential), dissolved oxygen, turbidity, and conductivity. The Horiba U52 stands out in a certain way. It can calculate 11 measures of water quality simultaneously. These are pH, ORP, DO, turbidity, conductivity, salinity, water depth, TDS, SW- SG, and temperature. Rapid and reliable measurements are possible due to the design of the sensor array, which is crucial in water quality monitoring in real time. The U52 is designed to resist extreme environmental circumstances and can therefore be used in rivers, lakes, coastal waters, and sewage treatment plants. Its robustness is a result of its being waterproof; this makes it able to last long at worksites. An instrument that has more than one function at the same time helps save time for measurement while collecting useful information. The U52 is a such device since it can measure several water quality parameters concurrently thus speeding up operations while reducing reliance on many tools.

F. Water Quality Index

Water quality evaluation is of great importance to the conservation of the aquatic ecosystems' wellness and the general public's safety because of the dangers that may arise if the quality of water is compromised. A properly set up method for the lab testing of water samples is prerequisite for this task to be successfully accomplished. The numerous physical, chemical and biological characteristics, which are present in water bodies can be gathered, analyzed and understood based on the applied methodology. This allows the computation of a Water Quality Index (WQI), a numerical expression that encapsulates the overall condition of water resources in a summarized manner through the systematic testing. Through the use of this approach, scientists, environmentalists, and governmental agencies can determine the water quality, identify the possible pollutants, and then make the decision on priorities for the management of these actions to reduce the negative effects. The primary procedures of lab testing are described in this introduction, which are mainly concentrated on the sample collection, parameter selection, the laboratory analytical methods, data interpretation, and quality categorization. This approach in the end becomes the base for the actions and decision-making which are based on the proactive and well-informed actions with the aim of the maintenance and the improvement of the water quality for both the current and the future generations.

G. Water Quality Parameter

Water quality parameters are important factors to identify the health and safety of the water bodies that influence their appropriateness for various uses such as drinking, swimming, irrigation, and industrial processes. The physical and chemical properties to be utilized in the process of determining the level of contamination in surface and ground water collected from various locations are listed below:

Here are brief definitions for each of the parameters:

- 1) pH - A measure of the water's acidity or alkalinity, with a pH of 7 being neutral, below 7 acidic, and above 7 alkaline.
- 2) Color - The visible appearance of water, which can be affected by the presence of substances like sediments, algae, or industrial contaminants.
- 3) Turbidity - A measure of the cloudiness or haziness of water, caused by suspended particles such as dirt, dust, or algae.
- 4) Odour - The smell of the water, which can indicate the presence of organic matter, chemicals, or other contaminants.
- 5) Hardness - A measure of the concentration of calcium and magnesium ions in water, which can affect its suitability for various uses.
- 6) Calcium - A key ion in water that contributes to its hardness and can influence its taste and usability.
- 7) Alkalinity - A measure of the water's ability to neutralize acids, typically due to the presence of bicarbonates, carbonates, and hydroxides.
- 8) Total Solids - The total amount of dissolved and suspended solids in water, including minerals, salts, metals, cations, and anions.
- 9) Dissolved Oxygen - The amount of oxygen dissolved in water, essential for aquatic life and indicating water quality.
- 10) Temperature - The measure of water's thermal energy, affecting chemical reactions, biological processes, and overall water quality.
- 11) Sulphate - A type of anion in water, often from natural or industrial sources, which can affect water taste and quality.
- 12) Nitrate - A common anion in water, often from agricultural runoff or sewage, which can be harmful to human health in high concentrations.
- 13) Fluoride - An ion that can be beneficial in small amounts for dental health but harmful in excessive concentrations.
- 14) Chloride - A common anion in water, which can come from natural or industrial sources, affecting water taste and corrosion potential.
- 15) Iron - A metal ion in water that can cause discoloration, taste issues, and corrosion problems if present in high concentrations.

IV. STUDY AREA

A. General

The Indian Union Territory of Jammu and Kashmir contains the little town of Athwajan in its Srinagar district. It is located roughly 7.6 kilometers from Lalchowk, and 6.8 kilometers from Pampore. Athwajan has good access to the cities and towns close by. Athwajan has good road connectivity, with buses running frequently between it and important cities like Srinagar, Ganderbal, Awantipora, and Hyderpora. Railway Station, the closest train station, is around 7.6 kilometers away. The region surrounding Athwajan and Srinagar is mainly located between Pir Panjal Range, in the foothills of the Himalayas, according to geological theory. Through this region runs the Jhelum River, one of the great rivers of northern India. In the Pantha chowk Sadar Tehsil of Athwajan of the Srinagar district in Jammu and Kashmir, there are 876 families living in and around Athwajan [Lasjan]. As per the Population Census 2011, there are 5281 people living in the area, with 2645 men and 2636 women.

The latitude and longitude of the location are 34.0414 N to 74.8748°E, respectively. Athwajan is well-known for its industrial area, especially for the H.K cement industries big cement facility. Situated amidst lush greenery characteristic of the Kashmir region, it faces the Jhelum River. One of the main sources of water for Athwajan and the neighboring areas is the Jhelum River. It is used for a variety of things, including as industrial use, drinking water supply, and irrigation. Municipal water supply systems treat the river's water before making it available to the general population. The Uri dams were built alongside the Jhelum River or its tributaries in order to control water flow, store water for future uses, and produce hydroelectric power. Additionally, water for public use may be supplied by these reservoirs. The primary source of groundwater recharge, excluding inflow from upland areas, irrigated fields, and rivers, is rainfall. On the other hand, wells and tube wells are the main sources of groundwater discharge, as are effluent seepages from groundwater in the form of springs and base flow in streams, among other mechanisms.

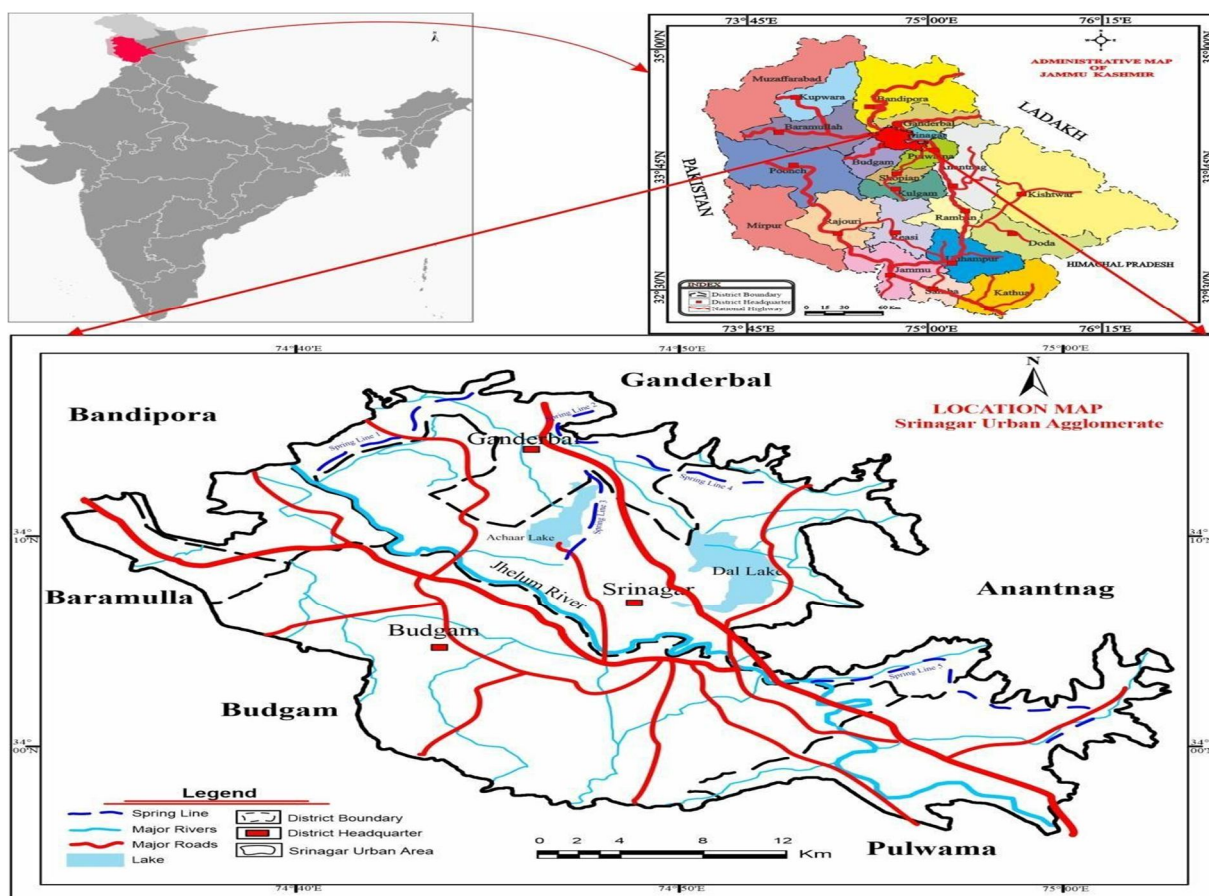


Fig. 4.1. Schematic of The Kashmir Valley

B. Climate and Rainfall

This region has a harsh winter with lows as low as -7°C to -15°C . In winter, a heavy fog surrounds the Jhelum for three months. During the summer, the hills and valleys are extremely parched. The rainy season brings with it more humidity and hot, muggy temperatures. The region experiences rainfall both in the non-monsoon (winter) and monsoon (June to September) periods. The coldest months of the year are January and February, while the hottest month is July during the summer, when temperatures can reach as high as 36°C . Rainfall occurs in the region primarily from May and October. There are 55 to 75 typical rainy days each year in the area, with an average annual rainfall of 825. mm.

C. Geo-morphology & Soil

The district of Srinagar is situated in the foothills of Himalayas, namely on the Pir Panjal range. Its terrain is varied, including piedmont zones and hills and valleys. The Kashmir Valley is a deep basin between the Pir Panjal Range and the western end of the Great Himalayas. The tallest peak, known as Mount Mahadev, is 3966 meters above sea level. The Jhelum rises from a deep spring in Verinag in western Jammu and Kashmir. The river meanders northwestern from the northern slope of Pir Panjal Range through the Vale of Kashmir to Wular Lake at Srinagar, which controls its flow. Emerging from the lake, the Jhelum flows westward and crosses the Pir Panjal in a gorge some 7,000 feet (2,100 metres) deep with almost perpendicular sides. At Muzaffargarh, the administrative centre of Azad Kashmir in the Pakistani-administered sector of Kashmir, the Jhelum receives the Kishanganga River and then bends southward, forming part of the border between Azad Kashmir to the east and Khyber Pakhtunkhwa province, Pakistan, to the west.

The river then flows southward into Punjab province. Near Mangla the Jhelum breaks through the Outer Himalayas into broad alluvial plains. At the city of Jhelum the river turns southwestward along the Salt Range to Khushab, where it again bends south to join the Chenab River near Trimmu.

The total length of the Jhelum is about 450 miles (725km). The district has two different types of soil: Hapludalfs and Ochraqualfs. Only the mountainous areas of the district are covered with non-calcic brown soil; the majority of the district is covered in alluvial soil. The soil is fertile and full with nutrients.

D. Regional Geology

The rocks that cover Jammu and Kashmir range in age from Precambrian to Recent. The subsequent thrusting event in the lower Himalayan region has an impact on these rocks. The rocks found in the district of Srinagar are from the Sirmur, Siwalik, and Shali groups. This district has rock groups that range in age from Middle Proterozoic to Early Pleistocene. The Shali group owns the lease area's geology. In addition to secondary Meso-Proterozoic Quartzite and Shale, the primary rock types in the Shali group are limestone and dolomite.

The limestone-rich Sirmur Group (Eocene to Early Miocene) is made up of sandstone, claystone, siltstone, and shale. Sandstone, clay, and conglomerate make up the Siwalik group, which spans the Middle Miocene to Plio-Pleistocene. The terrace deposits of sand and pebbles that are found along the Jhelum River and its tributaries are among the Quaternary sediments. This region's formation is thought to be Meso-Proterozoic in age, belonging to the Shali series. This fold in the limestone band is categorized as a reclining fold structure.

The folded limestone unit's vertical thickness is roughly 500 meters from the quarry's center. The deposit has a general NE-SW strike and a 40°–60° dip in the NW direction. The limestone strata in the quarry are nearly vertical in many spots. The thickness of the limestone bedding changes depending on which side of the quarry one is on. For example, the NW direction of the quarry primarily encounters thin bedded limestone, whereas the bedding thickness gradually increase in the direction of SE. Purple shale layers are stacked between pigmented fine-grained limestones. In certain areas, interstitial clay pockets are found to be cavity fills in the limestone. In the valley sections, the water table is found at a depth of 20 to 40 meters.

E. Topography

The mining lease region is a portion of the smaller Himalayan Mountains, which are distinguished by incredibly rough terrain with deep valleys cut into steep slopes and high peaks. The banks of the Jhelum River, which meanders between intermountainous basins and has a documented elevation of 233 mRL, provide elevation to the mountain that is home to the limestone deposit. The leasing area is located in Jammu and Kashmir's Himalayan hill ranges and is primarily hilly, having a landscape influenced by glacier and river activity throughout the Quaternary. The terrain is characterized by steep mountains, deep valleys, and a gradual mixing of various slopes and relief patterns.

F. Drainage Pattern

This area has a dendritic drainage pattern, with gullies being generated from the drainage that stretch over all of the flanks and converge at various points in several streams. Nala drains the mining lease's eastern and southern slopes. The Kashmir Valley is primarily drained by the Jhelum River which flows in a north-westerly direction through the central part of the valley. The Jhelum River directly joins the Western Drainage, thereby controlling it locally. To keep silt and water out of the village and nala, a set of parallel and series check dams have been built at the bottom of the mines.

G. Ground Water Status

Spring or nallah sources are typically used to meet the need for irrigation and home consumption. With little to moderate seasonal variation, the majority of these sources are perpetual. The irrigation department uses these sources in the future. The CGWB has conducted ground water investigation in the Srinagar district, although not throughout the district due to challenges with heavy machinery access. But for home use, the State Irrigation Department (I&FC) has dug a number of shallow bore wells with hand pumps in various districts.

These bore wells are between thirty and forty- five meters deep. Where there is a sufficient discharge, some of the wells are energized. In areas where the discharge is sufficient, some of the wells are charged. These hand pumps are situated in river basins and on hillsides with hard rock. Each of these valleys has tube wells constructed as well.



Fig. 4.2. H.K Cement Plant



Fig. 4.3. Sampling Area



Fig. 4.4. Ground Water Sampling

V. RESULTS AND DISCUSSIONS

A. Data Collection & Analysis of Water Quality

In this study, samples are collected from February through may in accordance with the Central Pollution Control Board's recommendations (Central Pollution Control Board Guidelines for Water Quality Monitoring Parivesh Bhawan East Arjun Nagar, Delhi-32, 2007). I collected and examined the samples from every station. I employed the Arithmetic Mean approach to analyze the water quality indexes. Each sampling site's average values for the parameter are used for WQI modeling. The data gathered from February, March, and April sample results are displayed in Tables. Calculating the WQI at several stations involves taking the average value of these factors, as depicted in the figure. The River's physio-chemical parameters' overall trend is displayed.

Table 5.1. Physical Parameters

WATER QUALITY INDEX	DESCRIPTION	GRADING
0-25	EXCELLENT	A
26-50	GOOD	B
51-75	POOR	C
76-100	VERY POOR	D
>100	UNSUITABLE FOR DRINKING PURPOSE	E

B. Surface Water Sampling Locations

Surface Water: The samples were collected from various sources.

Table 5.2. Sampling Locations (SW)

Station code	Sampling Stations	Distance & Direction
SW1	Jhelum River	200m in SW direction
SW2	Namblabal	~4.5 km in SE direction
SW3	Panthrathen	~4.0 km in NW direction
SW4	Khonmoh	~4.5 km in NE direction
SW5	Zooni pora	~4.0 km in ESE direction
SW6	Khrew	~7.5 km in East direction

C. Surface Water Sampling Locations on Map

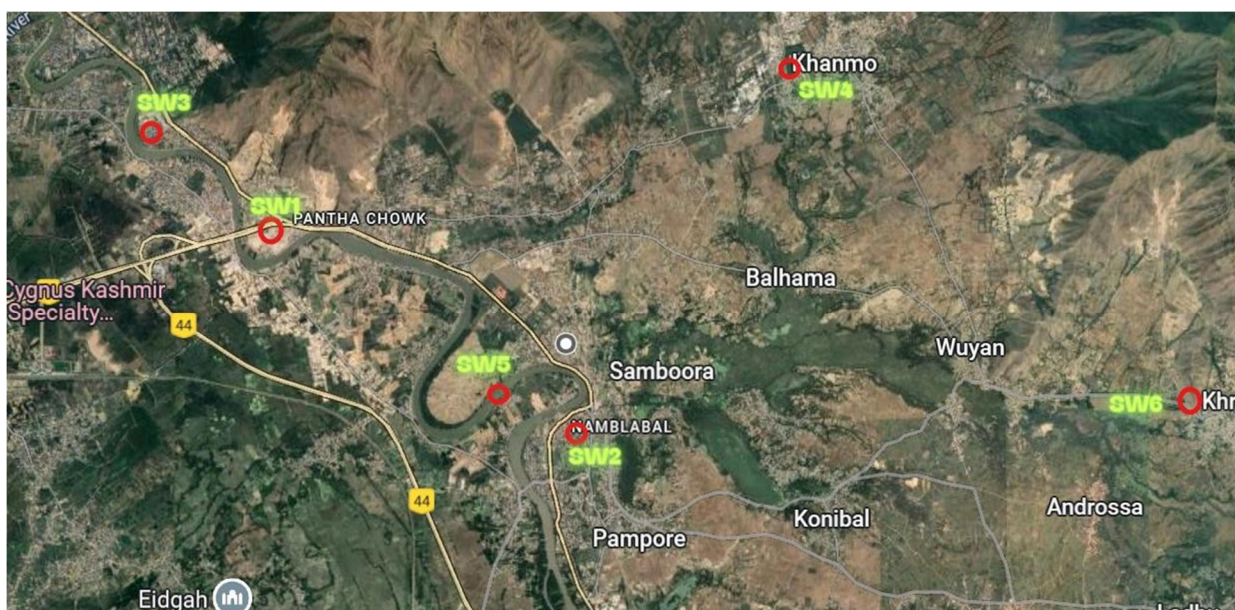


Fig. 5.1. Location of Surface Water Sampling

Table 5.3: Result of Jhelum River

S.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	7.24	7.35	7.20	7.42
2.	Colour	TCU	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	9.5	9.7	8.8	9.6
5.	Electric Conductivity	Mohs/cm	300	368.4	352.4	378.3	364.6

6.	Hardness	mg/l	200-600	205.2	213.26	216.35	204.15
7.	Alkanity	mg/l	200-600	218.8	185.23	190.46	209.4
8.	Total Dissolved Solids	mg/l	500-2000	543.2	524.5	548.7	531.8
9.	Sulphate	mg/l	200-400	34.36	34.02	32.56	35.14
10.	Nitrate	mg/l	45	2.93	2.78	2.91	2.65
11.	Fluoride	mg/l	1	0.55	0.51	0.49	0.54
12.	Iron	mg/l	0.3	0.21	0.22	0.24	0.20
13.	Calcium	mg/l	75	78.25	74.06	81.24	77.09
14.	Chloride	mg/l	250	28.26	28.30	27.09	29.42

Table 5.4 Result of Namblabal

Sr. No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	7.01	7.05	7.03	6.82
2.	Colour	TCU	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	7.8	7.7	7.8	7.6
5.	Electric Conductivity	Mohs /cm	300	300.6	303.4	298.3	304.6
6.	Hardness	mg/l	200-600	175.4	183.26	176.35	184.15
7.	Alkanity	mg/l	200-600	209.3	198.23	200.46	206.4
8.	Total Dissolved Solids	mg/l	500-2000	393.56	394.5	398.6	401.9
9.	Sulphate	mg/l	200-400	24.56	30.02	32.56	31.14
10.	Nitrate	mg/l	45	2.58	2.63	2.71	2.65
11.	Fluoride	mg/l	1	0.52	0.48	0.49	0.50
12.	Iron	mg/l	0.3	0.11	0.19	0.17	0.20
13.	Calcium	mg/l	75	43.24	54.06	51.24	47.09
14.	Chloride	mg/l	250	24.59	28.30	27.09	29.42

Table 5.5: Result of Panthrathen

Sr.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	8.03	7.85	7.89	7.92
2.	Colour	TCU	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	6.5	6.7	6.4	6.6
5.	Electric Conductivity	Mohs/cm	300	303.8	302.4	295.3	300.6
6.	Hardness	mg/l	200-600	158.3	163.26	166.35	154.15
7.	Alkanity	mg/l	200-600	164.2	175.23	169.46	170.4
8.	Total Dissolved Solids	mg/l	500-2000	353.43	364.5	368.3	351.09
9.	Sulphate	mg/l	200-400	30.25	33.02	32.06	34.14
10.	Nitrate	mg/l	45	1.62	1.78	1.91	1.85
11.	Fluoride	mg/l	1	0.39	0.42	0.46	0.40
12.	Iron	mg/l	0.3	0.07	0.09	0.07	0.08
13.	Calcium	mg/l	75	63.68	70.06	61.24	67.09
14.	Chloride	mg/l	250	27.48	28.20	28.09	29.02

Table 5.6: Result of Khonmoh

Sr. No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	7.61	7.59	7.60	7.58
2.	Colour	TCU	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	6.4	6.7	6.3	6.6
5.	Electric Conductivity	Mohs/cm	300	289.2	302.2	288.3	301.6
6.	Hardness	mg/l	200-600	158.2	153.26	156.35	150.15
7.	Alkanity	mg/l	200-600	203.6	195.23	193.46	208.4

8.	Total Dissolved Solids	mg/l	500-2000	320.42	314.5	308.6	311.9
9.	Sulphate	mg/l	200-400	32.42	31.02	32.36	30.24
10.	Nitrate	mg/l	45	1.69	1.68	1.7	1.65
11.	Fluoride	mg/l	1	0.36	0.37	0.34	0.35
12.	Iron	mg/l	0.3	0.09	0.10	0.12	0.11
13.	Calcium	mg/l	75	52.67	54.06	51.24	57.09
14.	Chloride	mg/l	250	22.13	24.30	27.03	25.42

Table 5.7: Result of Zooni pora

Sr.No	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	7.09	7.21	7.20	7.12
2.	Colour	TCU	5 (DL 1.0)	5 (DL 1.0)	5 (DL 1.0)	5 (DL 1.0)	5 (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	5.7	5.4	5.8	5.6
5.	Electric Conductivity	Mohs/cm	300	266.7	262.4	278.3	264.6
6.	Hardness	mg/l	200-600	156.6	163.56	156.35	154.10
7.	Alkanity	mg/l	200-600	200.5	195.23	187.46	188.4
8.	Total Dissolved Solids	mg/l	500-2000	296.32	304.4	308.8	301.7
9.	Sulphate	mg/l	200-400	23.36	24.02	22.46	25.04
10.	Nitrate	mg/l	45	1.44	1.39	1.41	1.45
11.	Fluoride	mg/l	1	0.17	0.15	0.19	0.20
12.	Iron	mg/l	0.3	0.12	0.13	0.13	0.14
13.	Calcium	mg/l	75	51.42	52.06	51.24	50.09
14.	Chloride	mg/l	250	24.90	28.30	27.09	29.42

Table 5.8: Result of Khrew

SR.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	6.79	6.55	6.60	6.62
2.	Colour	TCU	DL (DL 1.0)	DL (DL 1.0)	DL (DL 1.0)	DL (DL 1.0)	DL (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	5.06	5.12	5.08	5.10
5.	Electric Conductivity	Mohs/cm	300	220.1	212.4	218.3	214.6
6.	Hardness	mg/l	200-600	123.4	113.26	116.35	124.27
7.	Alkanity	mg/l	200-600	144.7	135.23	140.19	139.6
8.	Total Dissolved Solids	mg/l	500-2000	232.68	244.5	238.6	242.9
9.	Sulphate	mg/l	200-400	31.21	30.02	31.57	30.19
10.	Nitrate	mg/l	45	1.56	1.55	1.51	1.58
11.	Fluoride	mg/l	1	0.16	0.15	0.12	0.18
12.	Iron	mg/l	0.3	0.05	0.09	0.07	0.06
13.	Calcium	mg/l	75	42.03	44.06	41.24	46.09
14.	Chloride	mg/l	250	22.04	21.05	20.08	25.32

D. Ground Water Sampling Locations

Ground water as well as potable water samples were collected from the available water resources around the mine site i.e. Hand pumps and Bore wells. The samples were collected and tested from different sites. The quality of ground water was studied by collecting 6 water samples. The water samples were collected from Hand pumps/ bore wells. Details of ground water and soil sampling locations and their distance and directions are given

Table 5.9. Sampling Locations (GW)

Station code	Sampling Stations	Distance & Direction
GW1	Near Jhelum	~700m in SW direction
GW2	Near Ali Abad	~1.5 km in SE direction
GW3	Sem pora	~4.0 km in East direction
GW4	Natipora	~5.0 km in West direction
GW5	Khonmoh Village	~4.0 km in NE direction
GW6	Badamibagh	~Adjacent to MT boundary

E. Ground Water Locations on Map

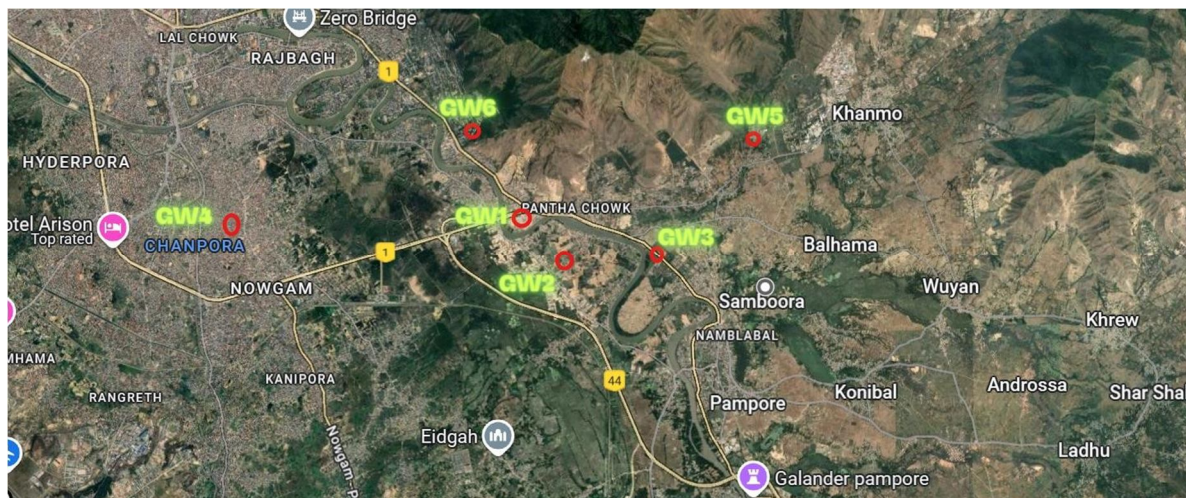


Fig.5.2. Location of Ground Water Sampling

Table 5.10: Result of Jhelum

Sr.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	6.08	6.04	6.07	6.09
2.	Colour	TCU	DL (DL 1.0)	DL (DL 1.0)	DL (DL 1.0)	DL (DL 1.0)	DL (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	9.3	9.5	9.2	9.3
5.	Electric Conductivity	Mohs/cm	300	620.14	625.23	619.25	622.40
6.	Hardness	mg/l	200-600	331.72	330.81	334.93	331.82
7.	Alkanity	mg/l	200-600	308.01	307.50	310.64	305.92
8.	Total Dissolved Solids	mg/l	500-2000	434.00	435.81	433.94	436.71
9.	Sulphate	mg/l	200-400	49.81	49.67	50.10	50.08
10.	Nitrate	mg/l	45	6.59	6.54	6.60	6.58
11.	Fluoride	mg/l	1	0.42	0.44	0.41	0.40
12.	Iron	mg/l	0.3	0.11	0.10	0.11	0.12
13.	Calcium	mg/l	75	87.14	85.13	87.11	87.09
14.	Chloride	mg/l	250	59.88	60.01	60.12	59.96

Table 5.11: Result of Ali Abad

Sr.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	6.14	6.20	6.22	6.15
2.	Colour	TCU	5 (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	8.6	8.6	8.4	8.5
5.	Electric Conductivity	Mohs/cm	300	660.12	665.23	659.01	664.09
6.	Hardness	mg/l	200-600	352.50	354.02	352.06	353.49
7.	Alkalinity	mg/l	200-600	319.32	319.08	318.90	318.08
8.	Total Dissolved Solids	mg/l	500-2000	496.04	498.07	500.01	499.06
9.	Sulphate	mg/l	200-400	67.24	67.29	68.01	67.45
10.	Nitrate	mg/l	45	9.86	9.88	9.83	9.90
11.	Fluoride	mg/l	1	0.38	0.39	0.38	0.36
12.	Iron	mg/l	0.3	0.16	0.14	0.15	0.16
13.	Calcium	mg/l	75	102.90	103.70	102.69	103.09
14.	Chloride	mg/l	250	82.47	83.01	82.49	82.79

Table 5.12: Sem Pora

Sr.No.	Parameters	Units	Std. Values as per BIS:10500 :2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	6.34	6.20	6.25	6.35
2.	Colour	TCU	5 (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	10.6	10.8	10.6	10.7
5.	Electric Conductivity	Mohs/cm	300	720.14	715.06	710.09	716.38
6.	Hardness	mg/l	200-600	430.61	434.68	431.25	430.58

7.	Alkanity	mg/l	200-600	423.34	422.36	422.28	423.30
8.	Total Dissolved Solids	mg/l	500-2000	598.07	597.06	588.09	598.04
9.	Sulphate	mg/l	200-400	73.64	73.58	73.68	73.65
10.	Nitrate	mg/l	45	8.45	8.46	8.43	8.42
11.	Fluoride	mg/l	1	0.35	0.33	0.35	0.32
12.	Iron	mg/l	0.3	0.17	0.17	0.16	0.14
13.	Calcium	mg/l	75	128.70	128.72	128.69	129.05
14.	Chloride	mg/l	250	87.40	88.04	87.06	87.39

Table 5.13: Result of NatiPora

Sr.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	7.68	7.64	7.69	7.70
2.	Colour	TCU	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)	L (DL 1.0)
3.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU	5	4.89	4.88	4.85	4.87
5.	Electric Conductivity	Mohs/cm	300	648.70	648.01	649.23	650.01
6.	Hardness	mg/l	200-600	289.14	289.20	290.01	298.40
7.	Alkanity	mg/l	200-600	265.34	265.39	265.40	265.33
8.	Total Dissolved Solids	mg/l	500-2000	350.0	350.64	350.12	350.56
9.	Sulphate	mg/l	200-400	33.77	32.90	33.68	33.76
10.	Nitrate	mg/l	45	3.64	3.63	3.66	3.64
11.	Fluoride	mg/l	1	0.29	0.27	0.29	0.28
12.	Iron	mg/l	0.3	0.06	0.06	0.07	0.07
13.	Calcium	mg/l	75	65.34	65.32	66.01	65.33
14.	Chloride	mg/l	250	54.97	54.99	54.97	55.02

Table 5.14: Result of Khonmoh

Sr.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	6.58	6.52	6.52	6.54
2.	Colour	TCU	DL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)
3.	Odour	-	Agreeable	eeabl e	eeabl e	eeabl e	eeabl e
4.	Turbidity	NTU	5	3.56	3.55	3.59	3.58
5.	Electric Conductivity	Mohs/cm	300	520.30	526.42	520.28	524.49
6.	Hardness	mg/l	200-600	336.62	336.69	336.80	336.59
7.	Alkanity	mg/l	200-600	309.36	310.45	309.45	309.39
8.	Total Dissolved Solids	mg/l	500-2000	458.01	457.09	458.07	458.00
9.	Sulphate	mg/l	200-400	41.76	41.56	41.78	41.48
10.	Nitrate	mg/l	45	8.54	8.54	8.51	8.52
11.	Fluoride	mg/l	1	0.39	0.38	0.36	0.39
12.	Iron	mg/l	0.3	0.09	0.07	0.09	0.08
13.	Calcium	mg/l	75	98.00	98.90	98.78	98.01
14.	Chloride	mg/l	250	79.47	79.49	79.50	79.46

Table 5.15: Result of Badamibagh

Sr.No.	Parameters	Units	Std. Values as per BIS:10500: 2012	Feb.	Mar	Apr	May
1.	pH	-	6.5-8.5	7.10	7.16	7.29	7.19
2.	Colour	TCU	DL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)	BDL (DL 1.0)
3.	Odour	-	Agreeable	eeab le	eeab le	eeab le	eeab le
4.	Turbidity	NTU	5	3.96	3.89	4.09	4.10

5.	Electric Conductivity	Mohs/cm	300	503.96	504.25	503.90	504.23
6.	Hardness	mg/l	200-600	381.2	381.26	381.90	382.01
7.	Alkanity	mg/l	200-600	375.78	375.02	376.08	375.79
8.	Total Dissolved Solids	mg/l	500-2000	534.0	536.68	535.39	535.89
9.	Sulphate	mg/l	200-400	59.62	59.80	59.96	60.03
10.	Nitrate	mg/l	45	12.62	12.72	12.56	12.63
11.	Fluoride	mg/l	1	0.48	0.46	0.44	0.48
12.	Iron	mg/l	0.3	0.13	0.12	0.13	0.14
13.	Calcium	mg/l	75	109.90	110.04	109.89	109.78
14.	Chloride	mg/l	250	92.47	92.49	93.01	92.46

F. Graphical Representation of Surface Water Analysis

Fig. 5.1. pH (Logarithmic scale 0 to 14)

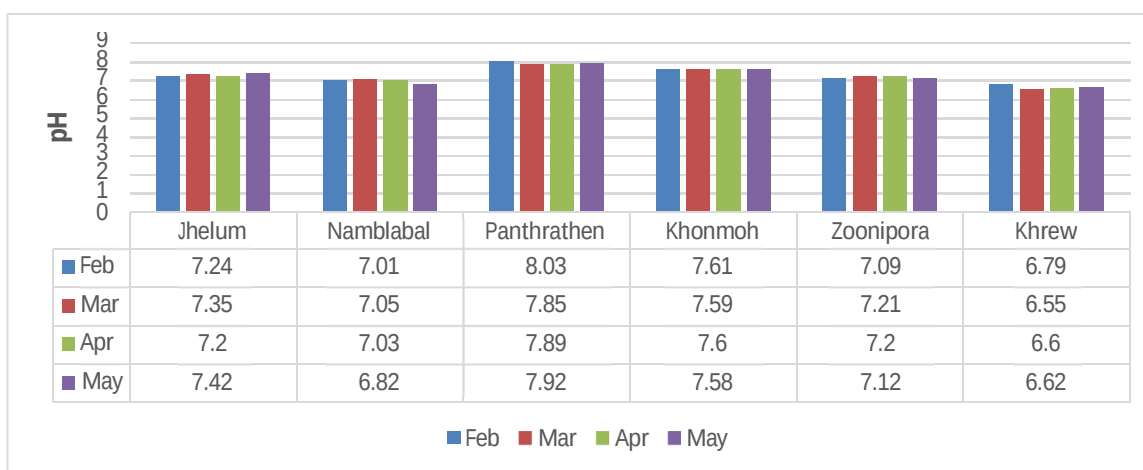


Fig. 5.2. Turbidity (Nephelometric Turbidity Units NTU)

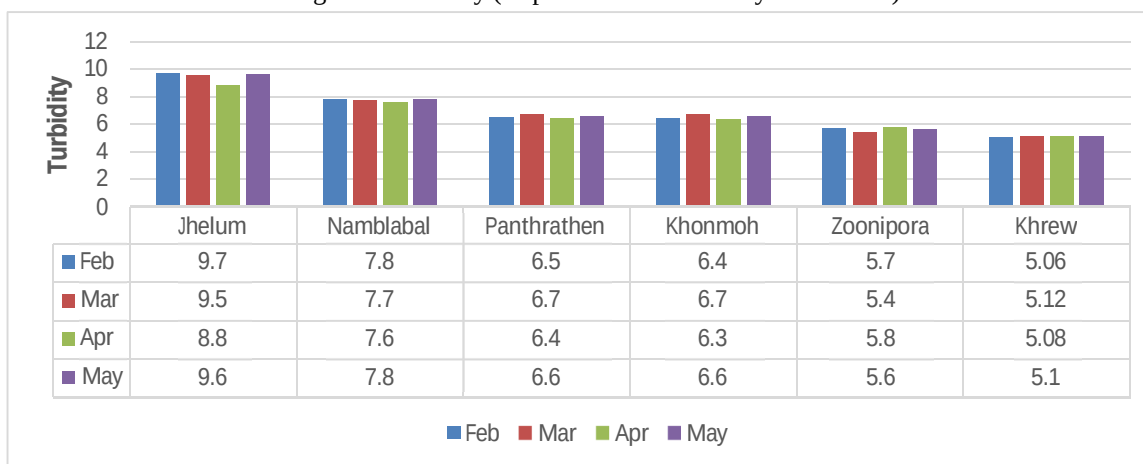


Fig. 5.3. Electric Conductivity (mohs/cm)

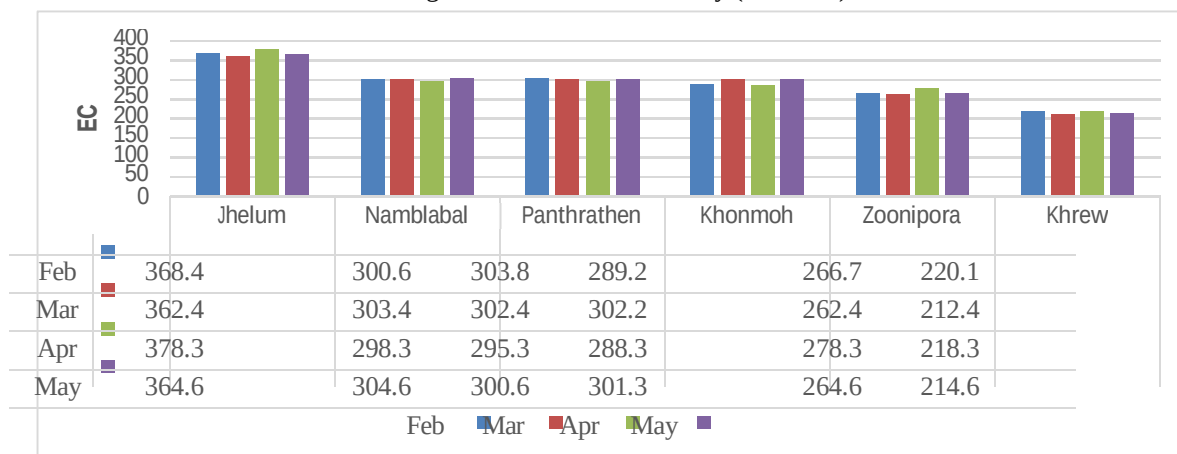


Fig. 5.4. Hardness (mg/l)

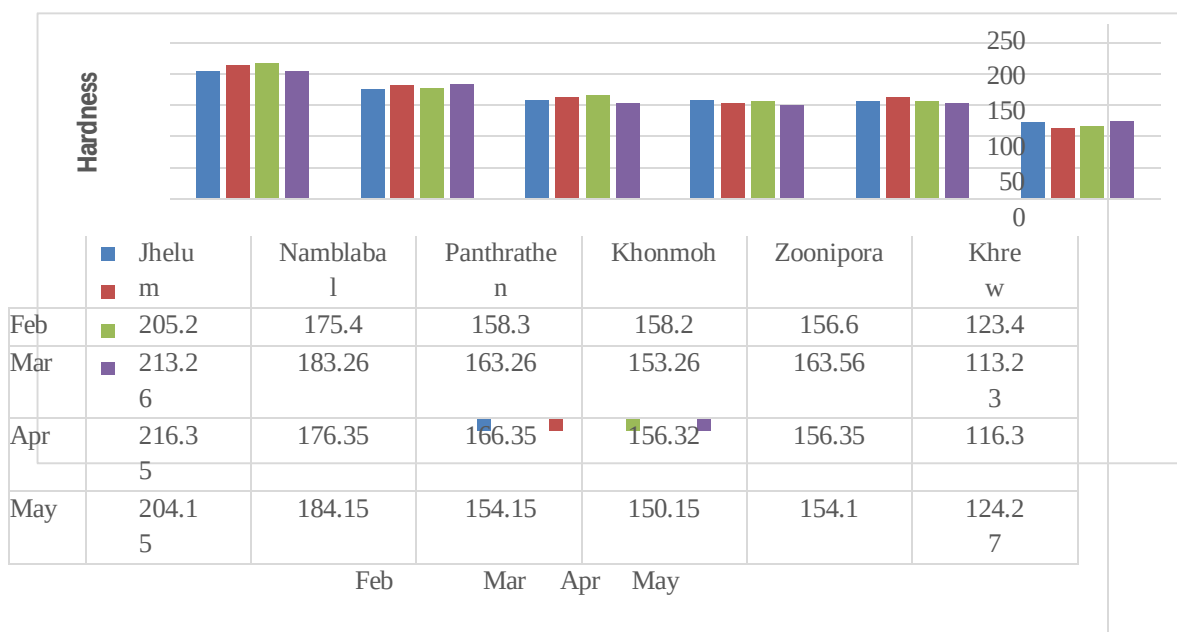


Fig. 5.5. Alkalinity (mg/l)

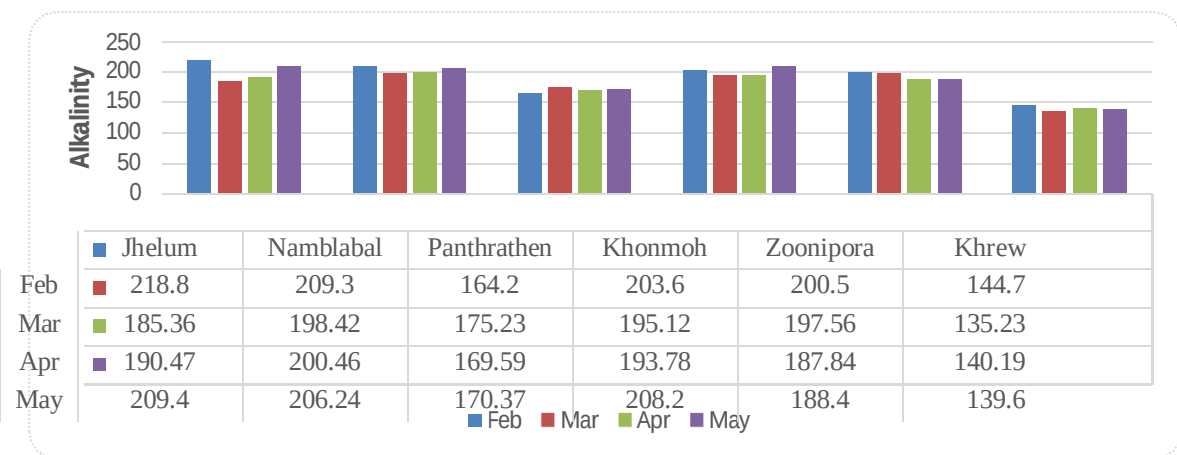


Fig. 5.6. Total Dissolved Solids (mg/l)

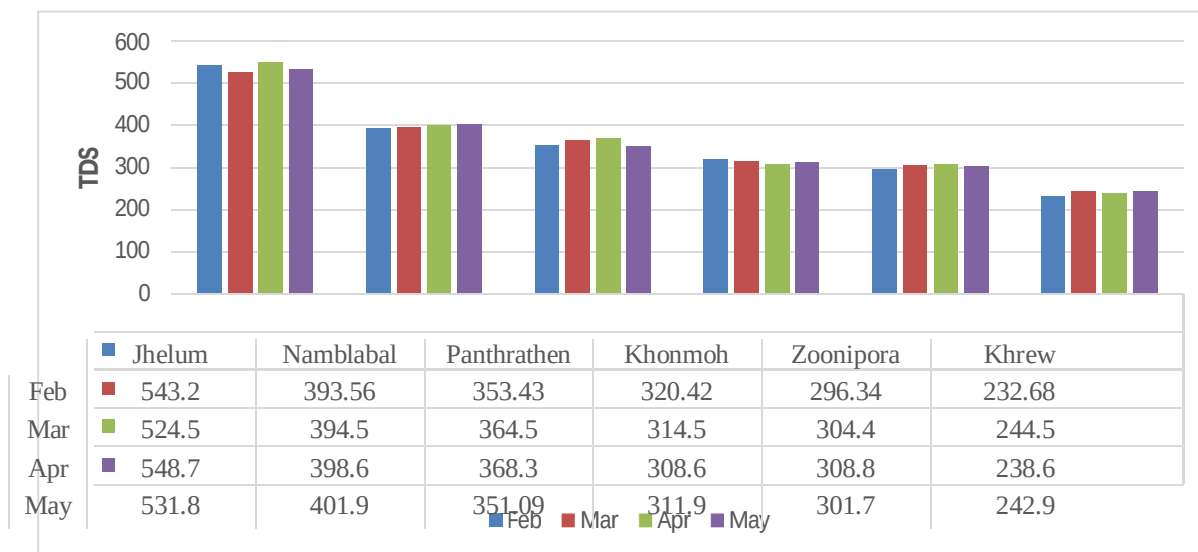


Fig. 5.7. Sulphate (mg/L)

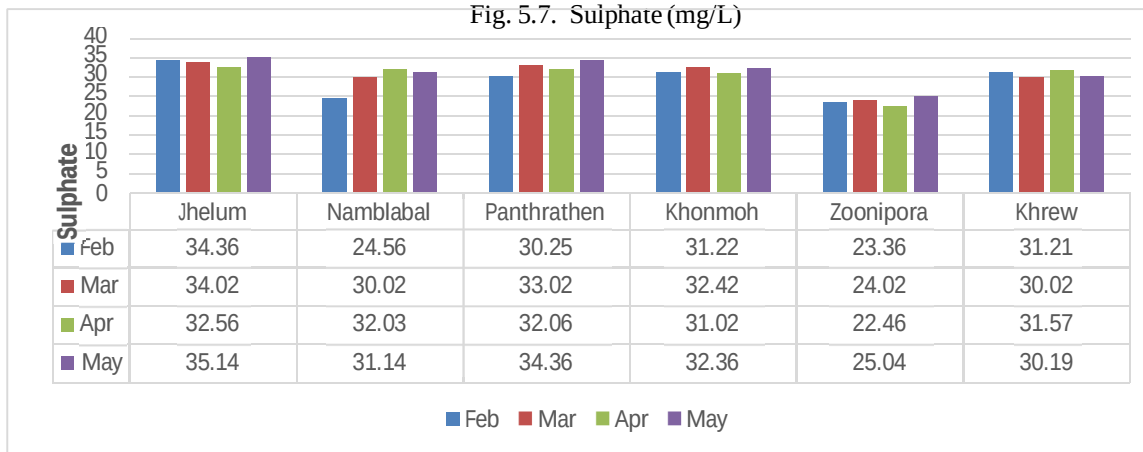


Fig. 5.8. Nitrate (mg/l)

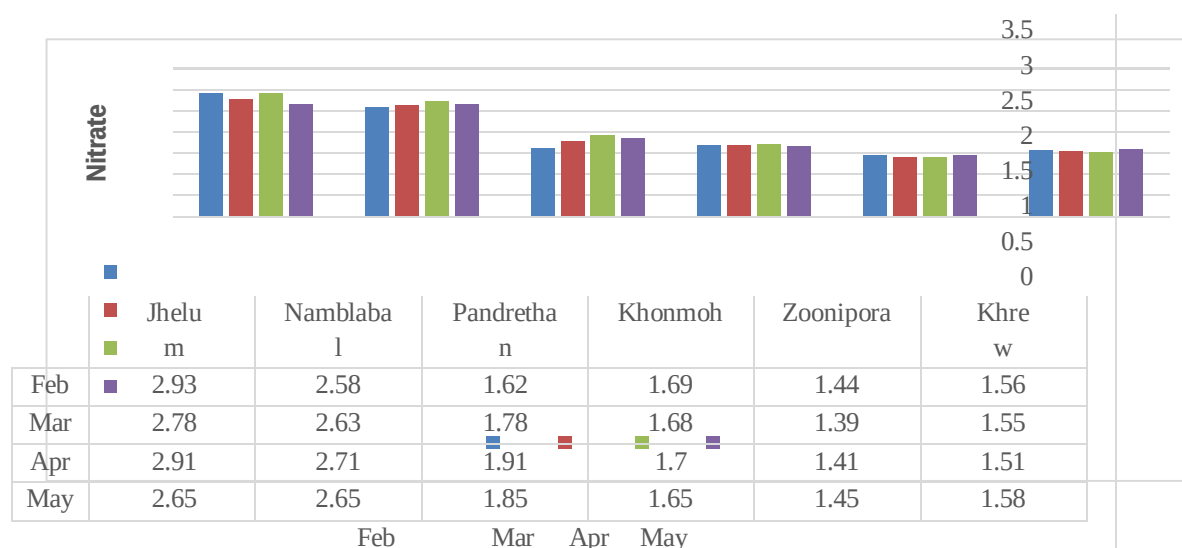


Fig. 5.9. Fluoride (mg/l)

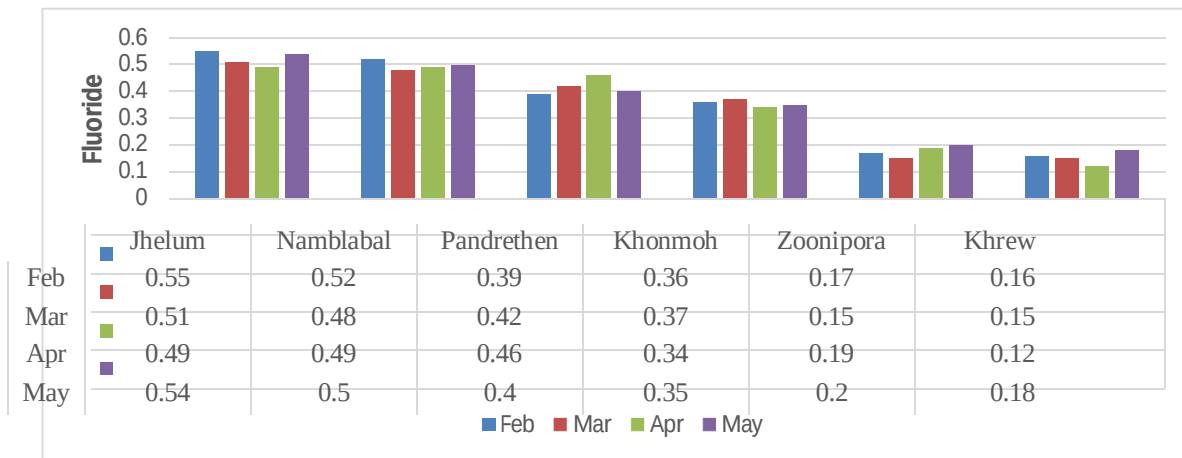


Fig. 5.10. Iron (mg/l)

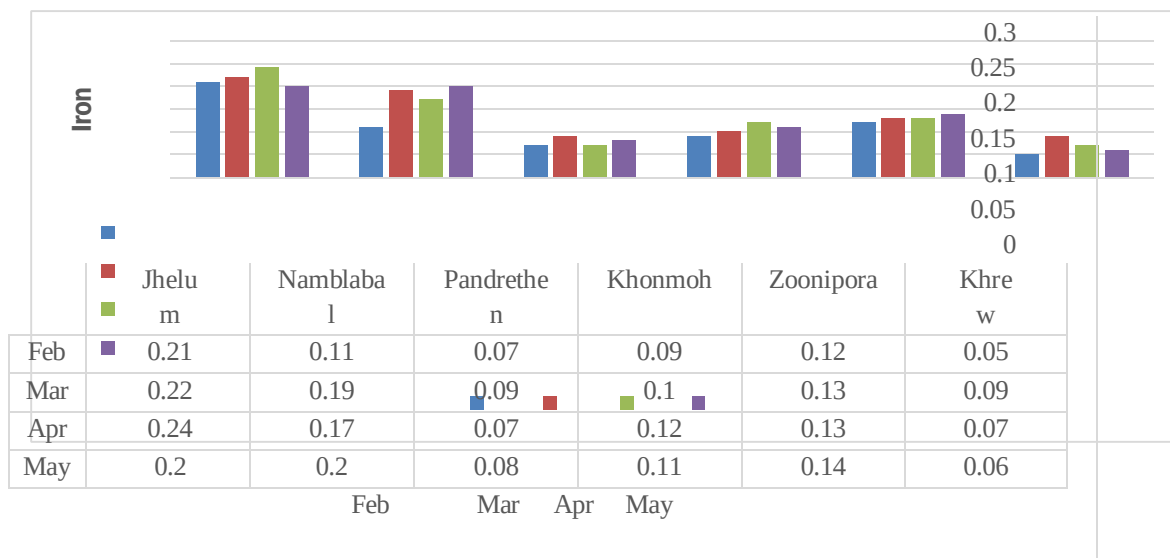


Fig. 5.11. Calcium (mg/l)

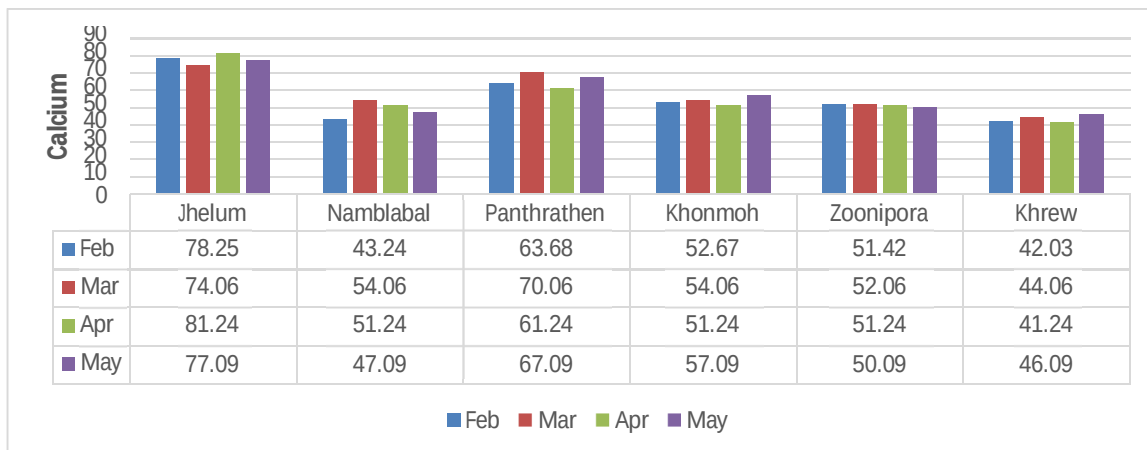
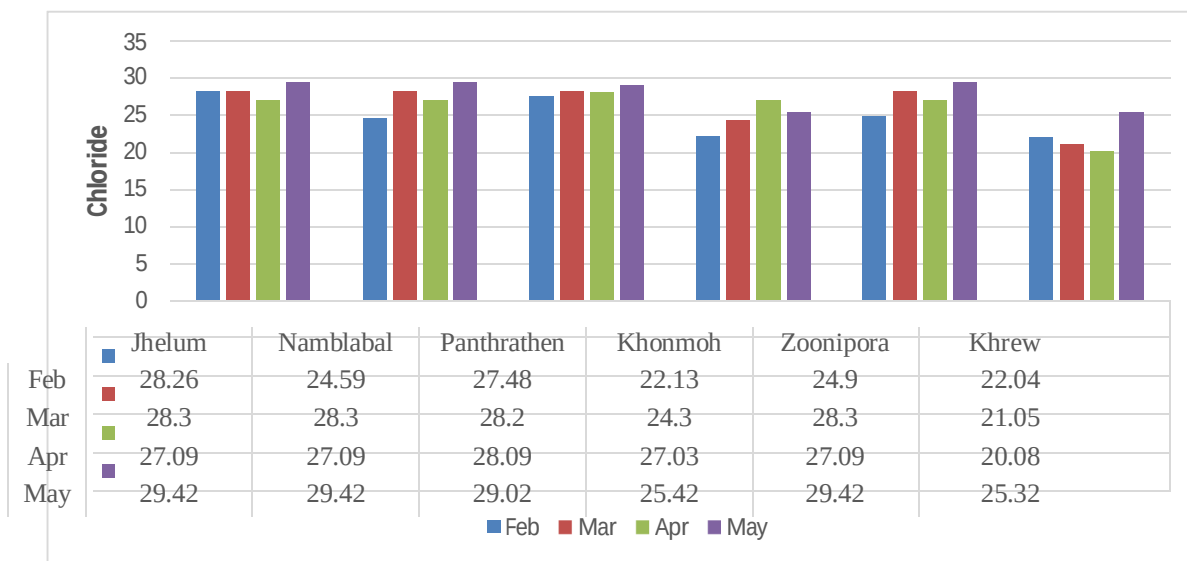


Fig. 5.12. Chloride (mg/l)



G. Graphical Representation of Ground Water Analysis

Fig. 5.13. pH (Logarithmic scale 0 to 14)

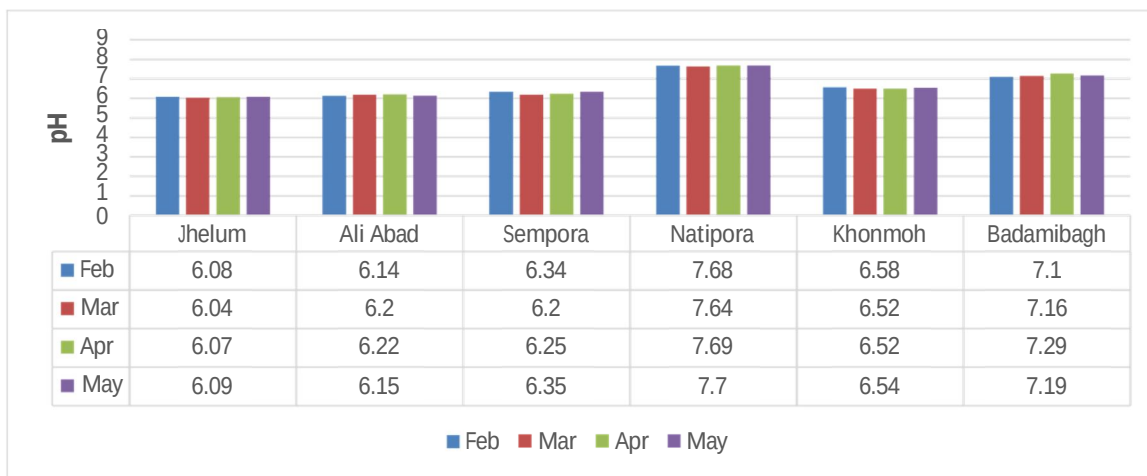


Fig. 5.14. Turbidity (Nephelometric Turbidity Units NTU)

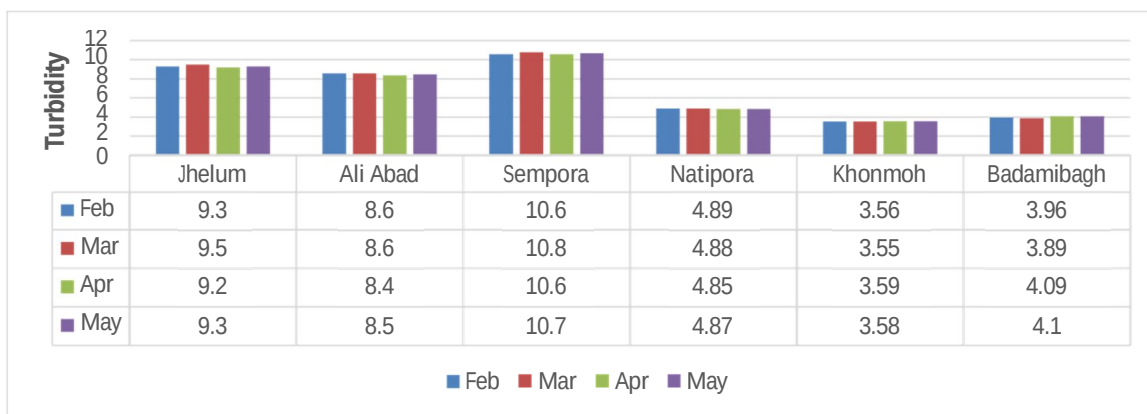


Fig. 5.15. Electric Conductivity (mohs/cm)

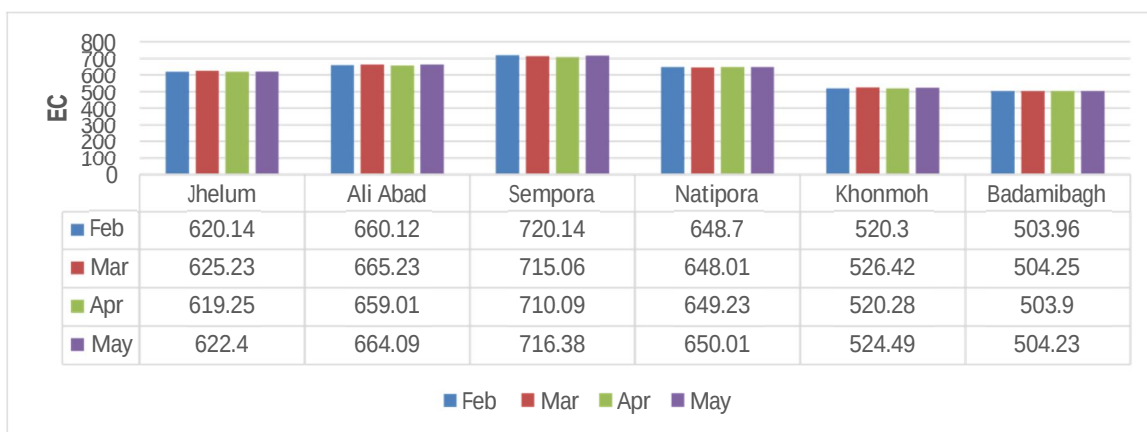


Fig. 5.16. Hardness (mg/l)

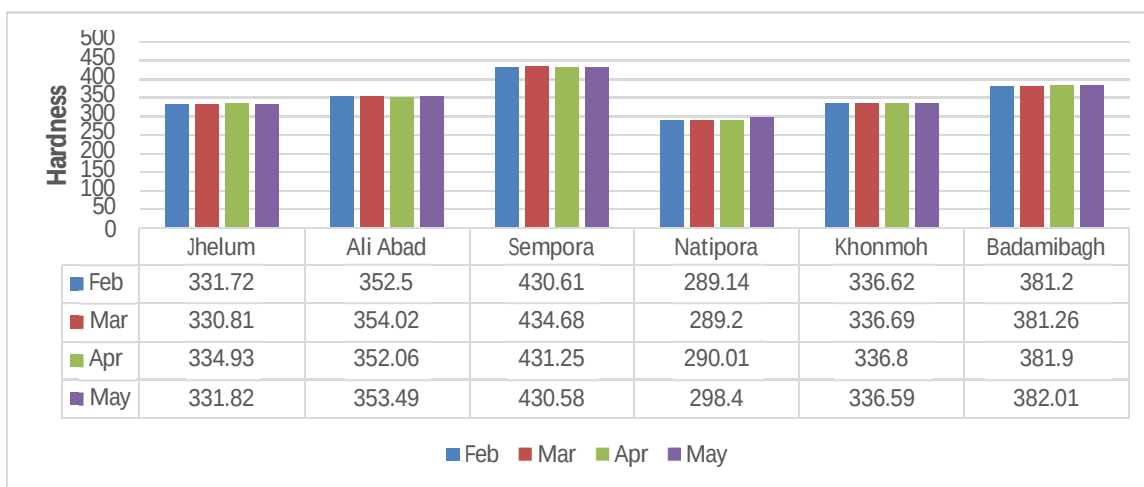


Fig. 5.17. Alkalinity (mg/l)

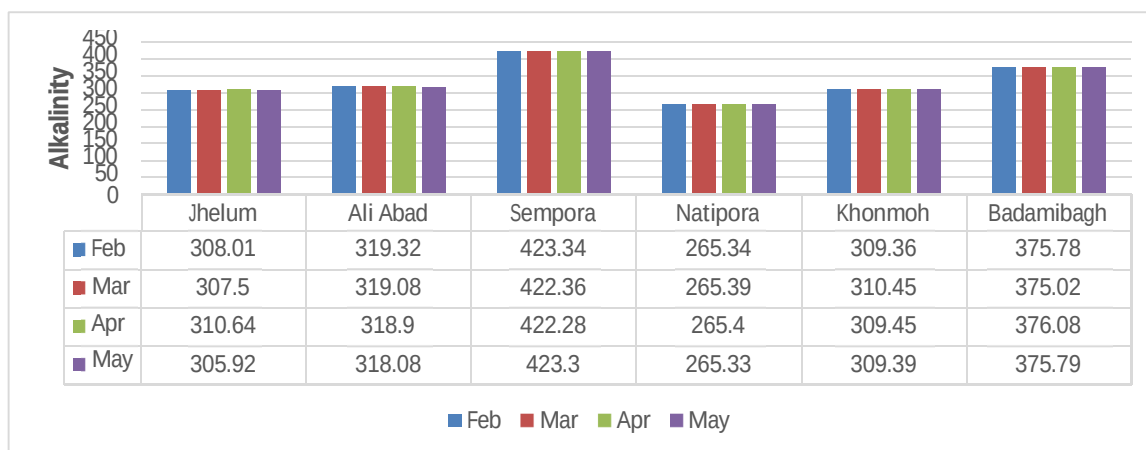


Fig. 5.18. Total Dissolved Solids (mg/l)

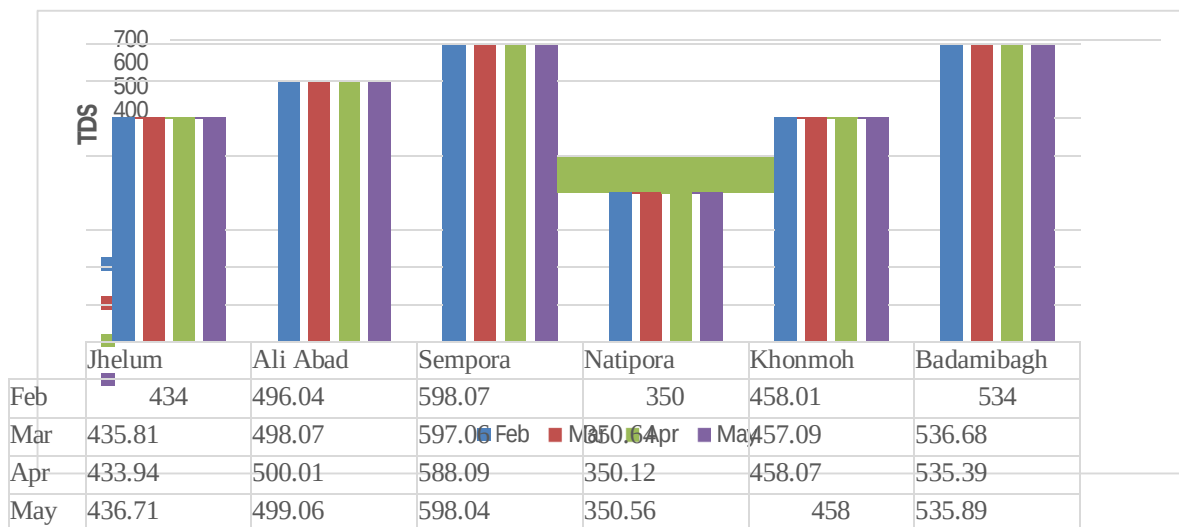


Fig. 5.19. Sulphate (mg/l)

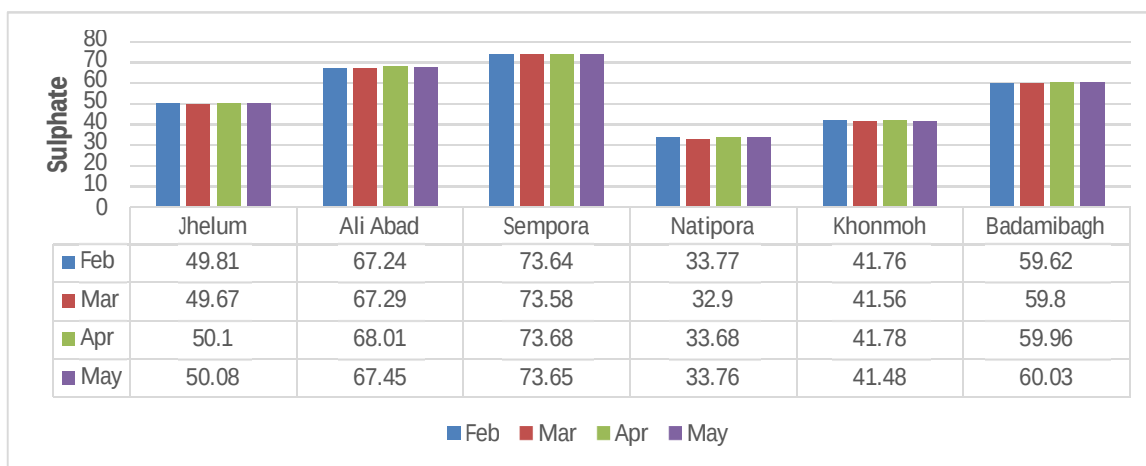


Fig. 5.20. Nitrate (mg/l)

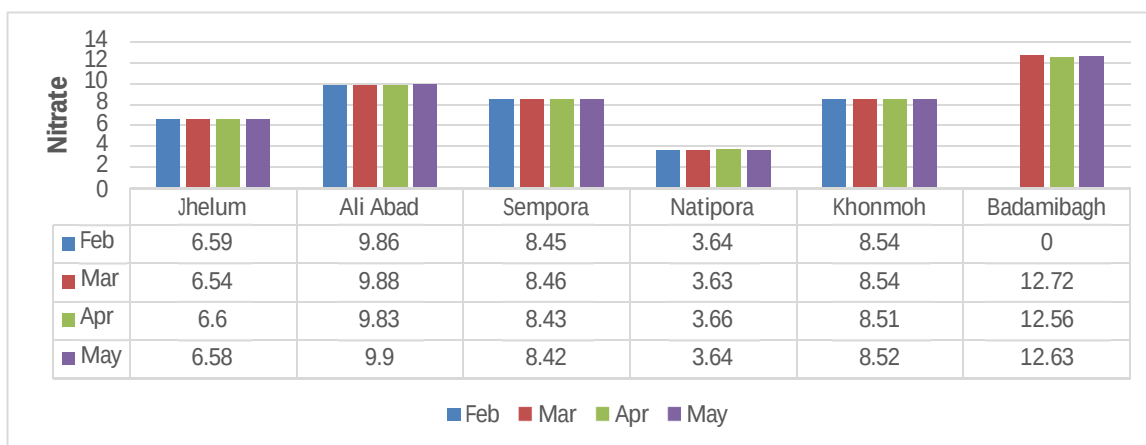


Fig. 5.21. Fluoride (mg/l)

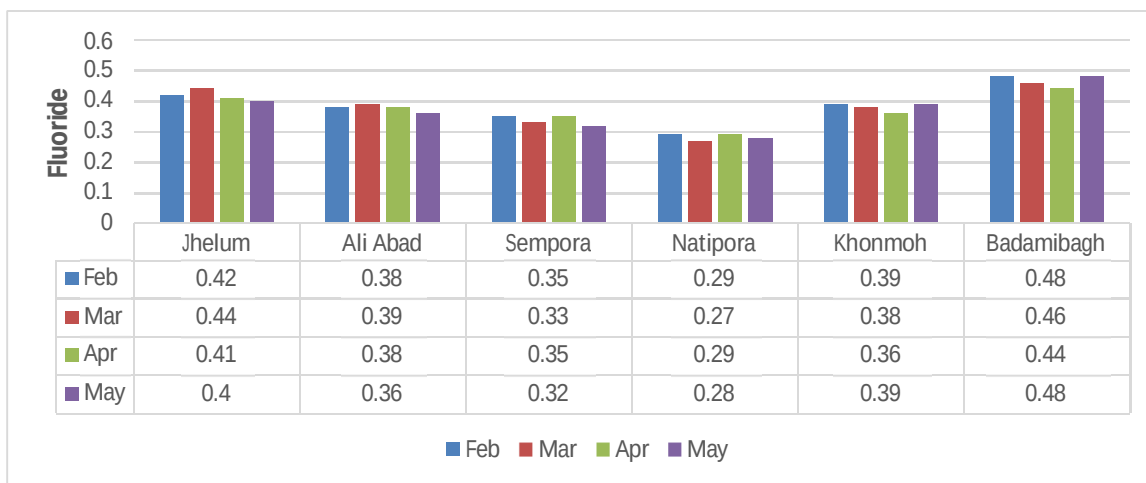


Fig. 5.22. Iron (mg/l)

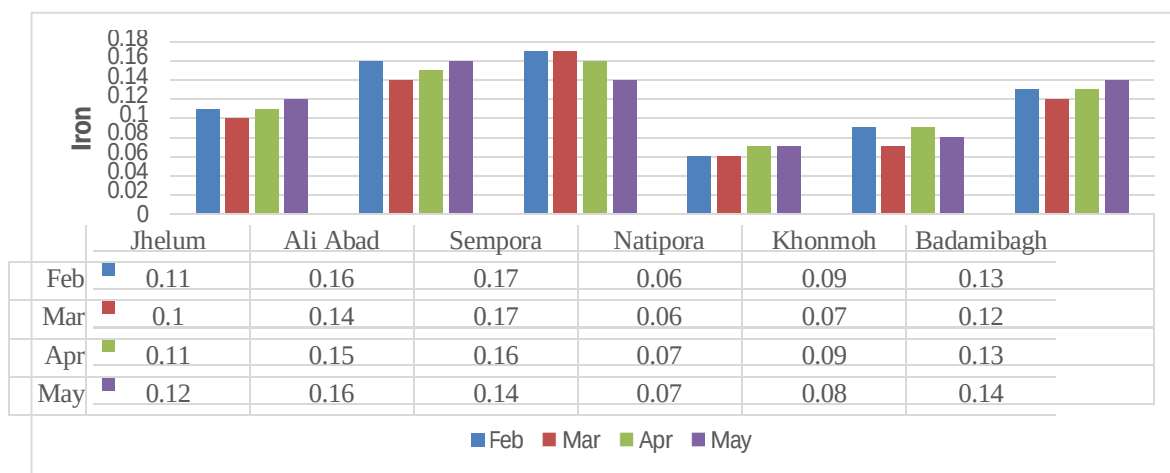


Fig. 5.23. Calcium (mg/l)

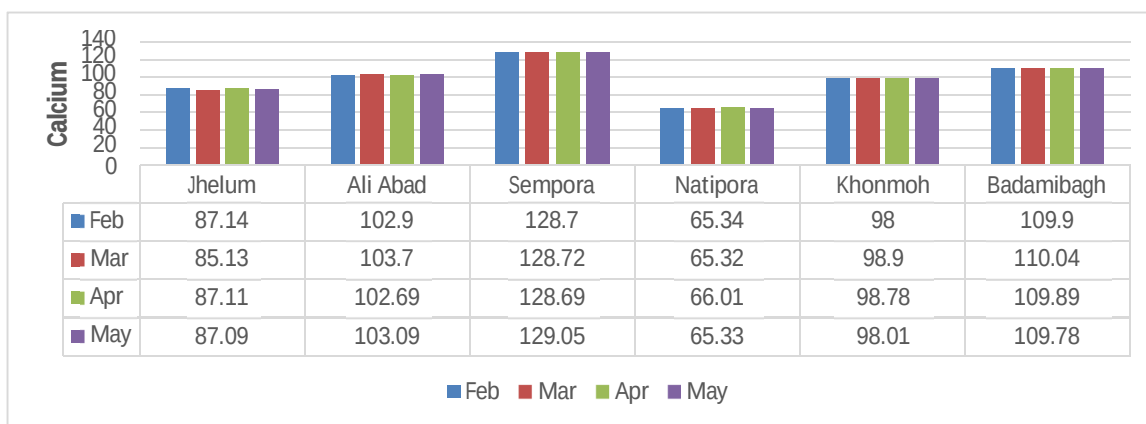
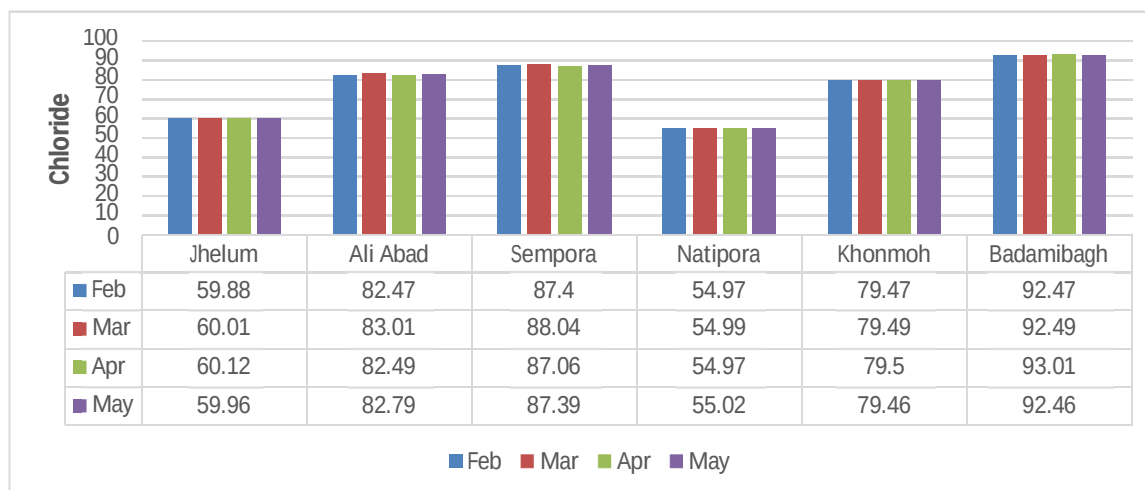


Fig. 5.24. Chloride (mg/l)



H. Discussion and Results

1) pH

The current water samples show a slight tendency toward alkalinity, as shown by the pH values in the range of 6.5 to 8.1. These readings are within the highest permissible level set by the WHO. Plumbing systems and fittings may experience faster corrosion if the pH rises above the permitted level. Can harm aquatic life also.

2) Turbidity

The health of ecosystems and the quality of water can be greatly impacted by excessive turbidity in surface and ground water. High turbidity hinders light penetration, which harms photosynthesis in aquatic plants and upsets the food chain. It is brought on by suspended particles including silt, clay, and organic matter. It can harm aquatic life's gills and slow down development and reproduction. Higher turbidity in drinking water increases the risk of waterborne infections by shielding dangerous germs from disinfection operations. It can also clog water filtration systems, increasing treatment costs and making water management initiatives more difficult. All things considered, keeping turbidity within allowable bounds is essential for safeguarding the environment and the general public's health.

3) Electric Conductivity

Cement leachate contains ions like Ca^{2+} , Cl^- , SO_4^{2-} , increasing EC, indicating **higher dissolved ions**. There are serious consequences for the environment and human health when surface and groundwater exceed their electric conductivity (EC) limits. Elevated quantities of dissolved salts and minerals are indicated by high EC, which can lower the quality of water and render it unfit for industrial, agricultural, and drinking purposes. High EC water in agricultural settings can cause salinization of the soil, which lowers crop yields and damages plant health. Because many aquatic creatures are sensitive to salinity changes and may suffer stress or even die, changes in salinity can have an impact on aquatic ecosystems. High EC levels can also cause infrastructure and pipes to corrode, raising maintenance costs and possibly contaminating surfaces due to rusted components. It is essential to monitor and control EC levels in order to preserve ecological balance and safeguard water supplies.

4) Hardness

Elevated due to leaching of **calcium and magnesium** from cement waste and raw materials.

High calcium and magnesium concentrations, which indicate excessive hardness in ground and surface water, can have a number of detrimental impacts. It may result in the accumulation of scale in pipes and appliances, shortening their lifespan and efficiency. In addition, this accumulation may result in higher maintenance expenses and possible obstructions in water distribution networks.

Hard water can have an impact on crop yields in agriculture by altering the structure of the soil and lowering the efficacy of fertilizers. Furthermore, although while it poses no health risks, it may change the flavor of drinking water and reduce the efficacy of soaps and detergents, increasing their usage and raising the expense of cleaning procedures for both residential and commercial settings.

5) Alkalinity

Increased from **lime, calcium hydroxide**, and other alkaline substances in cement. Water quality and the ecology can be greatly impacted by excessive alkalinity in surface and ground water. Excessive alkalinity levels are indicative of high bicarbonate, carbonate, and hydroxide concentrations. This may result in harder water, which impacts how suitable the water is for industrial, agricultural, and drinking purposes. The pH balance can also be affected by excessive alkalinity, which could make the water more basic. By altering the solubility of nutrients and heavy metals, which can become more poisonous under basic conditions, this pH shift has the potential to damage aquatic life. Furthermore, excessive alkalinity can make water taste bad and look bad, which increases the cost of treating the water to make it safe to drink and use.

6) Total Dissolved Solids

Higher TDS due to soluble salts from clinker dust, kiln dust, and chemical additives. The combined concentration of all inorganic and organic components in a liquid in molecular, ionized, or micro-granular suspended form is referred to as total dissolved solids (TDS) in water. TDS levels in ground and surface water that are higher than allowable limits can have a number of negative impacts. Excessive TDS can make water unfit for drinking and farming by reducing its flavor and potability. Moreover, it may result in pipe scaling and lower boiler and water heater efficiency. Because they change the chemistry of the water and the ecosystem, high TDS levels can be harmful to aquatic life. Moreover, high TDS may be a sign of dangerous pollutants that are hazardous to ecosystems and human health, such as industrial pollutants or heavy metals.

7) Sulphate (SO_4^{2-})

Elevated due to **gypsum** and **SO_3 -based additives** in cement—can cause scaling and corrosion in pipes. Over allowable limits of sulfate in surface and groundwater can have a number of negative consequences. Water with high sulfate content may become less pleasant to drink and have an unpleasant flavor. When ingested in excessive quantities, it can also have laxative effects and produce dehydration, which poses health dangers, particularly to vulnerable groups like the elderly and newborns. Furthermore, high sulfate levels can cause plumbing systems to corrode and leak dangerous metals like lead and copper into the water supply. High sulfate levels have the potential to negatively impact aquatic ecosystems, changing the chemistry of the water and limiting the availability of vital nutrients that support plant and animal life. Controlling sulfate levels is essential to maintaining clean drinking water and safeguarding aquatic habitats.

8) Nitrate (NO_3^-)

Significant problems with the ecosystem and human health can result from excessive nitrate levels in surface and ground water. Exceeding the allowable limits, nitrates—which are frequently generated by septic tanks, industrial waste, and agricultural runoff—can contaminate water sources. High nitrate concentrations in drinking water can cause major health problems, especially for babies. These disorders include methemoglobinemia, also known as "blue baby syndrome," which affects the blood's ability to carry oxygen. Elevated nitrate levels have the potential to cause eutrophication in surface waters by inducing algal blooms. This process damages aquatic life and upsets ecosystems by reducing the amount of oxygen in the water. To lessen these negative consequences, controlling nitrate levels through efficient wastewater treatment and sustainable farming practices is essential.

9) Fluoride (F^-)

Considerable negative effects on the environment and human health can result from excessive fluoride in surface and ground water. Humans can develop dental and skeletal fluorosis, which is characterized by tooth mottling and damage to bones and joints, when fluoride levels rise beyond the advised limit of 1.5 mg/L. Fish and other aquatic life may become poisonous as a result of high fluoride concentrations, which can also have an impact on aquatic ecosystems. Fluoride can also change the chemistry of the soil, which can have an impact on plant health and agricultural output.

In order to lessen these negative effects and guarantee safe water quality for human consumption and environmental health, efforts to regulate fluoride levels are crucial.

10) Iron (Fe)

Iron may leach from **corroded equipment** or **raw material**, increasing iron concentration. The ecosystem and public health may suffer when iron concentrations in ground and surface water surpass allowable thresholds. High iron content can stain water, making it look rusty or brownish. This can make the water unsightly and unfit for many purposes, such as drinking, gardening, and industrial processes. High iron content in water can have negative health impacts in addition to cosmetic difficulties. Hemochromatosis is one disorder that has been connected to iron overload in the body. This disorder can cause major health problems, including organ destruction.

11) Calcium (Ca^{2+})

Very common; increased levels due to **limestone**, **clinker**, and **lime** used in cement production. Aquatic ecosystems and human activities may be impacted in a number of ways when calcium levels in ground and surface water beyond their natural limitations. Water hardness may rise as a result of high calcium concentrations, interfering with industrial operations including water treatment and manufacturing. Further decreasing water flow and possibly causing infrastructure damage are scaling issues in pipes and water fixtures caused by high calcium levels. Elevated calcium levels in aquatic habitats can change the pH balance and harm aquatic life. Changes in biodiversity and ecosystem dynamics may result from the fact that some species may flourish in hard water environments while others may find it difficult to adapt.

12) Chloride (Cl^-)

Chlorides may increase from **chemical admixtures**, affecting taste, corrosivity, and suitability for irrigation. Aquatic ecosystems and human health may suffer when chloride levels in surface and groundwater surpass permissible limits. A number of factors, such as road salts, industrial discharge, and agricultural runoff, can lead to elevated chloride concentrations. High chloride levels in surface water can upset the osmoregulation of fish and other species, which can lead to decreased biodiversity and, in severe situations, even fish kills. Chloride can also worsen water quality and safety by accelerating the deterioration of infrastructure, including pipelines and bridges. Excessive levels of chloride in groundwater can make the water unsafe to drink or use for agriculture because of its saline flavor and possible health hazards, especially for people with renal or hypertension. Furthermore, soil salinity can be made worse by chloride contamination, which can have an impact on ecosystem health and agricultural output.

I. Water Quality Index

The Water Quality Index (WQI) provides an overall water quality number that can be used for any purpose. It is described as a score that reflects the combined impact of The water quality index (WQI) was calculated by taking into account various criteria related to water quality. One of the best ways to inform the public, policymakers, and those involved in water quality management about trends in water quality is through the use of indices. The intended use of water determines the relative importance of several parameters in the construction of the water quality index. The majority of the time, this is done with consideration for human consumption. Calculation of WQI was carried out in this work by Horton's method. The WQI is calculated by using the expression given in Equation.

$$WQI = \sum q_n W_n / \sum W_n$$

Where, q_n = Quality rating of n th water quality parameter. W_n = Unit weight of n th water quality parameter.

J. Quality rating (q_n)

The quality rating (q_n) is calculated using the expression given in Equation $q_n = [(V_n - V_o) / (S_n - V_o)] \times 100$

Where,

V_n = Estimated value of n th water quality parameter at a given sample location.

V_o = Ideal value for n th parameter in pure water. (V_o for pH = 7 and 0 for all other parameters)

S_n = Standard permissible value of n th water quality parameter.

Unit weight

The unit weight (W_n) is calculated using the expression given in Equation. $W_n = k / S_n$

Where,

S_n = Standard permissible value of n th water quality parameter. k = Constant of proportionality and it is calculated by using the expression given in Equation.

$$k = [1 / (\sum 1 / S_n = 1, 2, \dots, n)]$$

K. Standard Values & Unit Weight of Water Quality Parameters of Study Area

The selection of water quality measures is predicated on their direct correlation with the decline in water quality suitable for human consumption. The Indian Standards Institution (ISI) and Indian Council of Medical Research (ICMR) drinking water standards are taken into account while calculating unit weights (W_n) and quality ratings (q_n). Twelve water quality criteria have been chosen in order to calculate the WQI for the study area. TDS, pH, TA, EC, Turbidity, CA, TH, NO_3 , Cl, Fe, FL and SO_4 are those. In certain study area samples, the values of these parameters are found to be much higher than the allowable limits. The WQI value would rise with greater values for these parameters. The standard values of water quality parameters and their corresponding ideal values and unit weights are given in Table.

Table 5.16. Standard Values & Unit Weight of Water Quality Parameters of Study Area

S. No	Parameters	S_n	recommending Agency for S_n	Ideal Value (V_o)	k value	Unit weight $w_n=k/S_n$
1.	pH	8.5	IS	7	0.2123696847	0.0249846879
2.	EC	300	IS	0	0.2123696847	0.0007078995
3.	TU	5	IS	0	0.2123696847	0.0424739694
4.	TDS	500	IS	0	0.2123696847	0.0004247397
5.	TA	200	ICMR	0	0.2123696847	0.0010618492
6.	TH	300	ICMR	0	0.2123696847	0.0007078995
7.	NO_3	45	IS	0	0.2123696847	0.0047193299
8.	Cl	250	IS	0	0.2123696847	0.0008494794
9.	Fe	0.3	IS	0	0.2123696847	0.70789949
10.	SO_4	200	IS	0	0.2123696847	0.001061849
11.	FL	1	IS	0	0.2123696847	0.212369847
12.	Ca	75	IS	0	0.2123696847	0.002831598

Site 5.15 Feb											
PARAMETERS	S_n	$1/S_n$	$\sum 1/S_n$	$k=1/(\sum 1/S_n)$	$W_n=k/S_n$	Ideal Value V_o	Mean Conc. Value= V_n	V_n/S_n	$V_n/S_n \times 100=Q_n$	$W_n Q_n$	$\sum W_n Q_n / \sum W_n$
Ph	8.5	0.1176471	4.70920261	0.212350175	0.024982	7	7.1	0.835294	83.52941176	2.086763	47.37999256
EC	300	0.0033333	4.70920261	0.212350175	0.000708	0	503.96	1.679867	167.9866667	0.118907	47.37999256
TU	5	0.2	4.70920261	0.212350175	0.04247	0	3.96	0.792	79.2	3.363627	47.37999256
TDS	500	0.002	4.70920261	0.212350175	0.000425	0	534	1.068	106.8	0.045358	47.37999256
TA	200	0.005	4.70920261	0.212350175	0.001062	0	375.78	1.8789	187.89	0.199492	47.37999256
TH	300	0.0033333	4.70920261	0.212350175	0.000708	0	381.2	1.270667	127.0666667	0.089942	47.37999256
NO_3	45	0.0222222	4.70920261	0.212350175	0.004719	0	12.62	0.280444	28.04444444	0.132339	47.37999256
Cl	250	0.004	4.70920261	0.212350175	0.000849	0	92.47	0.36988	36.988	0.031418	47.37999256
Fe	0.3	3.3333333	4.70920261	0.212350175	0.707834	0	0.13	0.433333	43.33333333	30.6728	47.37999256
SO_4	200	0.005	4.70920261	0.212350175	0.001062	0	59.62	0.2981	29.81	0.031651	47.37999256
FL	1	1	4.70920261	0.212350175	0.21235	0	0.48	0.48	48	10.19281	47.37999256
Ca	75	0.0133333	4.70920261	0.212350175	0.002831	0	109.9	1.465333	146.5333333	0.414885	47.37999256
		4.7092026			1					47.37999	

Table 5.17. WQI at Site 1

Site 5.3 Feb												
PARAMETERS	S_n	$1/S_n$	$\sum 1/S_n$	$k=1/(\sum 1/S_n)$	$W_n=k/S_n$	Ideal Value V_o	Mean Conc. Value= V_n	V_n/S_n	$V_n/S_n \times 100=Q_n$	$W_n Q_n$	$\sum W_n Q_n / \sum W_n$	
Ph	8.5	0.1176471	4.70920261	0.212350175	0.024982	7	7.24	0.851765	85.17647059	2.12791	72.07645416	C
EC	300	0.0033333	4.70920261	0.212350175	0.000708	0	368.4	1.228	122.8	0.086922		C
TU	5	0.2	4.70920261	0.212350175	0.04247	0	9.5	1.9	190	8.069307		C
TDS	500	0.002	4.70920261	0.212350175	0.000425	0	543.2	1.0864	108.64	0.046139		C
TA	200	0.005	4.70920261	0.212350175	0.001062	0	218.8	1.094	109.4	0.116156		C
TH	300	0.0033333	4.70920261	0.212350175	0.000708	0	205.2	0.684	68.4	0.048416		C
NO3	45	0.0222222	4.70920261	0.212350175	0.004719	0	2.93	0.065111	6.511111111	0.030725		C
Cl	250	0.004	4.70920261	0.212350175	0.000849	0	28.26	0.11304	11.304	0.009602		C
Fe	0.3	3.3333333	4.70920261	0.212350175	0.707834	0	0.21	0.7	70	49.54837		C
SO4	200	0.005	4.70920261	0.212350175	0.001062	0	34.36	0.1718	17.18	0.018241		C
FL	1	1	4.70920261	0.212350175	0.21235	0	0.55	0.55	55	11.67926		C
Ca	75	0.0133333	4.70920261	0.212350175	0.002831	0	78.25	1.043333	104.3333333	0.295403		C
		4.7092026			1					72.07645		

Table 5.18. WQI at Site 5.3

VI. CONCLUSIONS AND SCOPE FOR FUTURE WORK

A. Conclusion

The present study highlights the significant impact that cement industries exert on ground and surface water resources. The findings indicate that cement production activities, including raw material extraction, dust deposition, and discharge of untreated effluents, contribute to the deterioration of water quality parameters such as pH, electrical conductivity, total dissolved solids (TDS), chloride, calcium, and heavy metals. These changes not only threaten aquatic ecosystems but also pose serious health risks to nearby human populations relying on these water sources. It is evident that the proximity of cement industries to water bodies accelerates the contamination rate, particularly in unregulated or poorly monitored facilities. In addition, excessive groundwater extraction for industrial processes can lead to depletion of aquifers, affecting the long-term sustainability of water availability for surrounding communities. Thus, stricter regulatory enforcement, adoption of cleaner technologies, regular water quality monitoring, and sustainable water management practices are essential to mitigate the adverse environmental impacts of the cement sector.

B. Scope for Future Work

- 1) Longitudinal Studies: Future research can involve long-term monitoring of water quality parameters to observe trends and better assess cumulative impacts over time.
- 2) Heavy Metal Analysis: A more detailed investigation into the presence and bioaccumulation of heavy metals (e.g., lead, cadmium, chromium) in aquatic organisms and soils is recommended.
- 3) Groundwater Modeling: Advanced hydro geological modeling could be used to simulate groundwater flow and pollutant transport in areas surrounding cement industries. Use of Remote Sensing and GIS: Integrating satellite data and GIS tools can help map land use changes, water body shrinkage, and pollution hotspots more effectively.

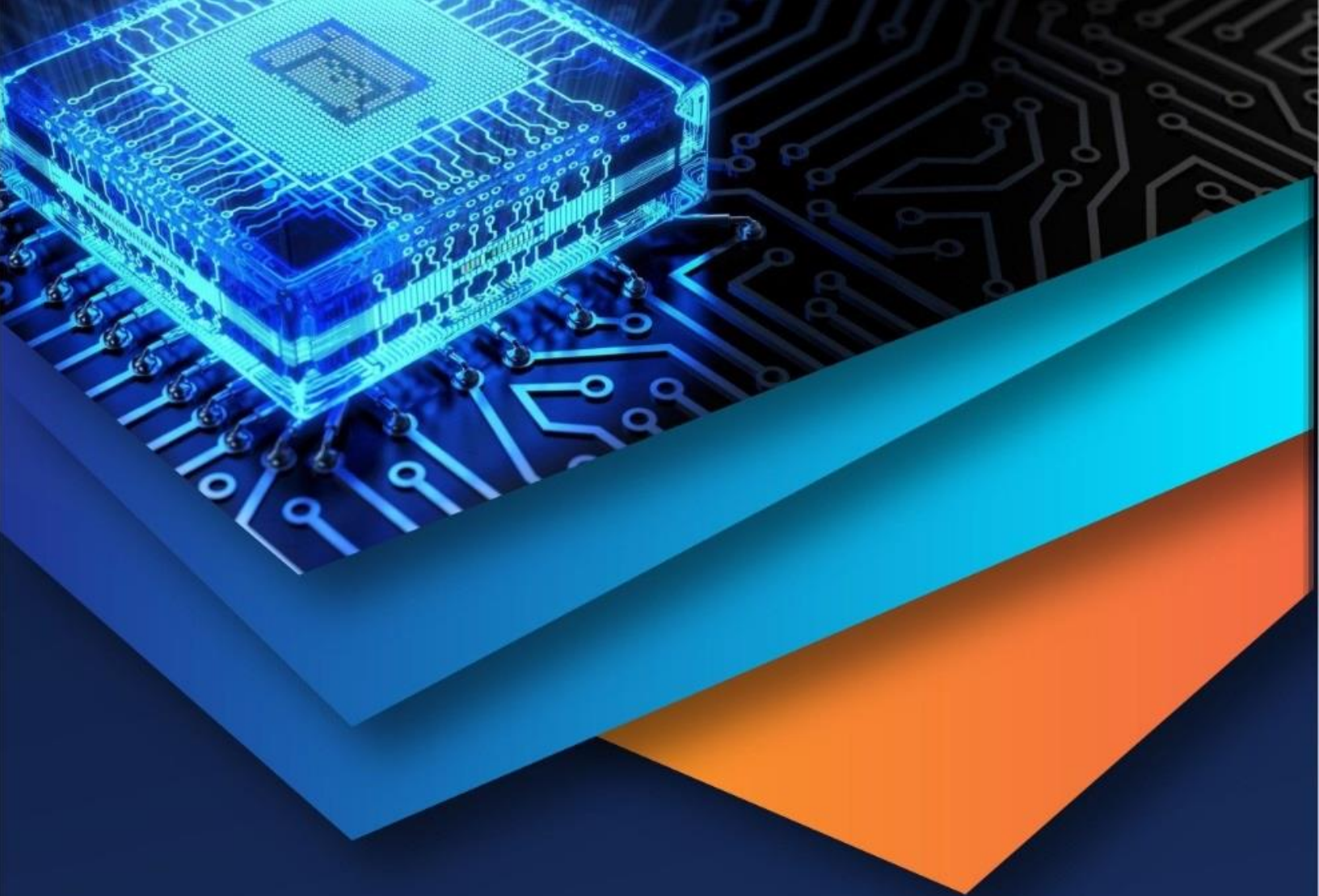
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