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Qualitative Assessment Of Water Using Flame Photometer And GIS Techniques

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Abstract- *In this study, we have examined 11 samples of water taken from different points e.g. Shallow, river, and underground water, in order to test presence of Na+ and K+ ions in Bhopal region, Madhya Pradesh, India. To determine the proportional contributions of human and natural events, we have plotted the arc GIS maps to represent how the vitiated Na+ and K+ ions are distributed in space in the surface and groundwater sources in the Bhopal region of Madhya Pradesh. Additionally, the "water quality index (WQI)" is generated to check that surface, river & underground water test samples gathered are suitable for occupants of those region to consume. The test sample of location the PMAY site exhibited the least potassium and sodium, according to observations concentration of 41 mg/l and 04 mg/l respectively. The water of location B1 (Mandideep) has the maximum Na+ and K+ concentration of 66 mg/l and 14 mg/l respectively. Total samples had WQI values of less than 50, which means they are all safe for human consumption. To keep the "Water Quality Index (WQI)" in acceptable ranges, suggestion is to limit the application of water softeners and pesticides.*

Keywords- *Arc GIS, Flame Photometer, Potassium, Sodium, Water Quality Index (WQI), Water Qualitative Assessment*

INTRODUCTION

Water quality assessment is crucial for understanding the health of aquatic ecosystems and ensuring the safety of water resources for human consumption and various other uses (Bindu et al., 2023). Traditional methods of water quality monitoring often involve the analysis of physicochemical parameters, providing valuable insights into the levels of pollutants and other factors impacting water quality (Khatri et al., 2021). However, these methods may have limitations in capturing the full complexity of water quality, especially in dynamic environments influenced by multiple factors (Boudeffa et al., 2020). Integrating advanced analytical techniques like flame photometry with spatial analysis tools such as Geographic Information Systems offers a more comprehensive and holistic approach to water quality assessment (Qualitative Assessment of Water Using Flame Photometer and GIS Techniques in Bhopal, India.). Flame photometry is a sensitive analytical technique used to determine the concentration of certain quantitative analysis of K+ and Na+ metal ions in a sample. (Banerjee and Prasad, 2020). Atomic emission is considered an important and useful instrument for uncovering of trace elements. Many factors must be taken into account to establish a reliable & accurate atomic emission method, incorporating optimal atomization and excitation source selection, slit width and wavelength selection,reducing interference from outside chemicals and spectral lines, and standardization approaches (Basheer & Baqi, 2020). The invention of the nebulizer, which makes it possible to introduce the sample within the air/acetylene flame in the form of an aerosol, has sped up the development of the flame photometer. Earlier, emission was recorded photographically and scattered by a quartz prism spectrum. As a result, the flame photometer, a low-cost instrument with high sensitivity, was created to quantify the concentration of Na+ and K+ ions in samples with accuracy. (Muchiri, Kipkurgat, Thomas, Samuel,Andrew & Chibole et.al., 2021) Concepts of additional accurate techniques, like atomic absorption spectroscopy (AAS) and inductively coupled plasma atomic emission spectroscopy (ICPAES), were also discovered to achieve the aim of other metals determination. For Na+ and K+ ions determination, flame photometers have a high resolutionFlame photometry is an optical technique for atomic emission spectra-based quantitative elemental analysis. Spectra are produced in the flame by the analyte turning into an atomic vapor. An example of an atomic emission spectral analysis is thermal flame photometry (Basheer & Baqi, 2020). Minor excitation is detected from devices operating in the 1000–3000 °C range. Lower excitation temperature from flame than arc flame, makes this method most suitable for alkali metals, which include

Ca, Ba, etc. When it comes to identifying the aforementioned alkali and alkaline earth metals to a large degree, the Flame photometer offers clear advantages over the costly AAS and ICP-AES processes. ICP-AES is preferred over flame photometry for detecting metal ions, although this approach performs sodium and potassium ion detection at a much lower efficiency than flame photometry, making the latter the best candidate. When group II compounds made of alkali metals and alkaline earth are placed in the flame, they break into individual atoms (Jinwal & Dixit, 2008). The atoms are stimulated to greater states during dissociation. However, they become unstable at higher levels and return to the ground state by emitting light with a distinctive wavelength. They release visible spectrum color as they revert to their initial ground condition. Additionally, it is important to remember that each alkali & alkaline metal has a distinct wavelength. According to the element's concentration in the sample, the quantity of energy absorbed in the flame at the characteristic wavelength (Somtochukwu, 2020). Sodium is not harmful to a person as long as their intake is within the permissible limit, which is obtained from food and water. But for people who have heart and kidney issues, as well as those who have trouble sleeping, sodium intake becomes a problem (Praveen, 2022). It is suggested that they eat foods with reduced salt content. Since Bhopal is one of the most significant cities in central India, it has a sizable population. Since the lakes and surface water in and around Bhopal are major sources of available water for the city's inhabitants thus it is crucial to analyze the Na+ and K+ content. It is crucial to look into the quantity of Na+ and K+ contents in the existent water sources in order to identify health dangers for school-age children and older people. Subsurface waters are chemically polluted and unfit for drinking or domestic use in regions where agriculture and aquaculture are practiced (State, 2019). Therefore, before using the water for different purposes, precise water treatment techniques like ultrafiltration and nanofiltration are used to lower the higher amounts of dissolved solids (Krishnakartik, Satyaveni & Machiraju et.al.,2020).Another crucial method for reducing the size of the data sets to a score that users and policymakers can easily understand is the creation of a water quality index (WQI). It uses an index number to represent the water quality (Tiwari, 2019). The several organizations in charge of managing water supplies and water pollution are greatly assisted by this index because it is a useful instrument for simple comprehension, making its application straight forward (Taluk & Rumuri, 2020). These approaches make it incredibly simple and clear to use datasets on water quality, and they aid policymakers in choosing how to allocate resources and define priorities. The ability to represent water quality in terms of WQI enables a better assessment of the circumstances of water quality in various locations and, as a result, a better allocation of resources to the areas that need them the most (Somtochukwu, 2020). The collected water samples' water quality index (WQI) is afterward is observed to determine the combined impact of various water qualities, i.e., the presence of solutes, such as Na+ and K+ in this case, on the total quality of the water (B. & Sirieva, 2020). The WQI was calculated for each water sample to evaluate the water's quality and suitability of its drinking purpose for Bhopal region (Mohmood & Wani, 2020)

MATERIALS AND METHOD

2.1 Study Area

As show in Figure 1(a) and 1(b), water samples were gathered from a variety of sources, located in the Bhopal district of Madhya Pradesh, India. These regions have the highest population density of Bhopal city along with villages around Bhopal city. Consequently, the investigation was focused on these areas. The waters were collected from sources, Sector C Industrial Area Mandideep, Rahul Nagar, Industrial Area Mandideep, Narmada pipeline Bridge, samardha, MM Mandideep, Anand Nagar Area, RNTU campus, Bangrasia Bridge, Bhojpur kaliyasot river Bridge Near, Bhanpur ROB Bhanpur Construction site, Bhanpur Jain Temple, they are all located in the Indian state of Madhya Pradesh's city of Bhopal. A flame spectrophotometer was used to analyze all of the aforementioned water samples to determine whether sodium and potassium ions are present.

2.2 Experimental Procedure

11 samples of water were obtained from diverse water sources in Bhopal district, of these, 4 were surface water from ponds or rivers and 7 were subterranean water from wells and bore wells. A flame photometer was used to perform spectroscopic examination on these water samples. (American Public Health Association 1985 (A. Public and H. Association,2024).

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Fig. 1(a)

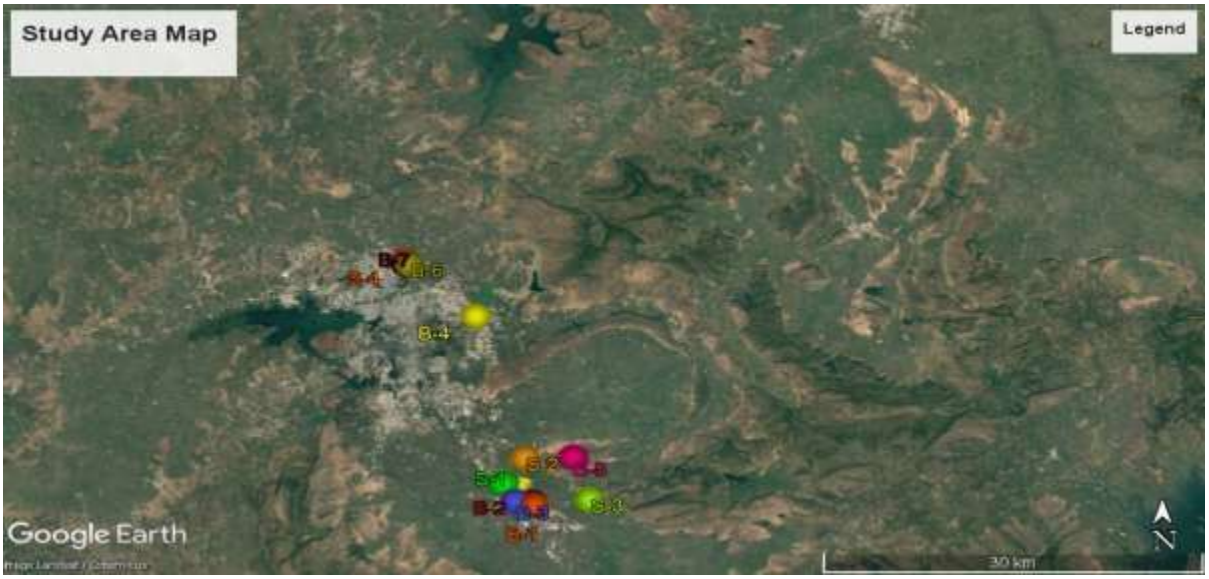

Fig. 1(b)

Figure 1 (a) and (b): Map showing the positions of water samples that were taken in Bhopal district.

Table 1 Characteristic wavelength and flame colour

Metals	**Wavelength**	**Flame colour**
Sodium	589 nm	Yellow
Calcium	622 nm	Orange
Lithium	670 nm	Red
Potassium	766 nm	Violet

The flame photometer was calibrated with the standard Na-K stock solution with a 30 ppm concentration. Each collected sample was diluted with 100 ml of water and placed in standard prescribed bottles for examination. Flame photometer was then used to analyze the water samples. All of the samples were taken in April, which was the height of summer, at an average temperature of 35 °C. For examination, all samples from the water sources were taken at once.

RESULTS AND DISCUSSION

Table 2 below provides a summary of the analysis outcomes as determined by the data from the flame photometer. The findings show that all of the water samples' sodium and potassium levels are far below the permitted limits established by the World Health Organization (WHO 1984) (State, 2019), (BIS 1991) (Krishnakartik,Satyaveni & Machiraju et.al.,2020). However, there have been documented differences in the amounts of Na+ and K+ between shallow water and underground water. The availability of Na+ in surface water is caused by a number of factors, which includes the infiltration of road salt, irrigation, precipitation, leaching through soils rich in sodium, ground-water pollution from sewage effluent, and the infiltration of landfill leachate from the Bhanpur site or industries. The potassium in groundwater may have been accidentally released in huge quantities, or it may have been added accidentally during the hard water ion exchange process. Another method of introducing potassium into water bodies is through water softeners, which are designed to lessen water's hardness. The Na+ and K+ ion in the examined samples, as can be seen in Figure 2(a), 2(b) for collected water samples, shows the relative weightage of Na+ and K+ ions found in the water collected from different sources in Bhopal district. The experimental result of Na+ and K+ content values in surface & underground water is shown in Tables 2 and Table 3. This suggests that subsurface water has a higher Na+ content than surface water, possibly as a result of the human activities mentioned above that have caused K+ in surface water to be greater than in subsurface water, and there is a significant likelihood that salt rock bed will be present very close to an underground water bed, which will cause the sodium ions to dissolve with it. Our understanding of the relationship between subsurface rock bed geology and human activity's effects on Na+ and K+ ions in water, as well as how these ions are affected by other metals in the water, will help us better understand the variations in Na+ and K+ content in the district where the sources of water samples are dispersed. It demonstrated that Na+ and K+ ions are present in greater concentrations in and around the Mandideep Industrial Area (kori,2019), (Verma & Kumar 2025) . In order to gain more knowledge of the water quality, the water quality index (WQI) is determined using the relative weightage of characteristics initiating at one and going up by the relevance of a specific mixed solute in the test samples. The highest characteristic will thus receive greater marking like 7, 8, etc., whereas the lowest characteristic will receive marking like 2, 3, etc.

Relative weight of each parameter is determined using the relation:

$$w_i = \sum_{i=1}^{n} \frac{w_i}{\sum_{i=1}^{n} w}$$

A parameter-based assessment of the quality of the water:

$$q_i = \left(\frac{C_i}{S_i}\right) X100$$

As per the rules set forth by the BIS (1991), Ci denotes the concentration of each chemical parameter in milligrams per liter of each water sample, whereas Si represents the standard for each chemical parameter in milligrams per liter.

$$SI_i = W_i \times q_i$$

is the ith parameter's subindex.

$$WQI = \sum_{i=1}^{n} SI_i$$

is the water quality index, which divides water into five categories ranging from unfit for human consumption to good; a table of these categories is provided below. In Table 3, it is stated whether or not the water samples are suitable for drinking (WHO 1984) based on the sodium and potassium concentration of the samples. As a result, we can get a general idea of the water's quality from the water quality index.

Table 2: shows the amounts of Na+ and K+ ions in the water samples after examined

Sample Detail	**Latitude**	**Longitude**	**Location**	**Concentration Na^+ of ions (mg/l)**	**Concentration of K^+ ions(mg/l)**
B-1	23.092697^0	77.533043^0	Sector C Industrial Area Mandideep	66	14

B-2	23.09585^0	77.53061^0	Rahul Nagar, Industrial Area Mandideep	63	6
S-1	23.111232^0	77.508619^0	Narmda pipeline Bridge, samardha	28	23
B-3	23.09666667	77.51805556	MM Mandideep	54	13
B-4	23.25361111	77.48583333	Anand Nagar Area	56	15
B-5	23.13335969	77.5624117	RNTU campus	61	11
S-2	23.13250000	77.52527778	Bangrasia Bridge	32	21
S-3	23.09777778	77.57555556	Bhojpur kaliyasot River Bridge	36	19
S-4	23.30083333	77.42972222	Near Bhanpur ROB	25	20
B-6	23.29750000	77.43361111	Bhanpur Construction site	41	4
B-7	23.29750000	77.43111111	Bhanpur Jain Temple	46	8

Table 3: show the water quality at the study location based on WQI values

Sample Detail	**Na^+**	**K^+**	**WQI**	**Water Quality**
B-1	66	14	13.26697709	Excellent
B-2	63	06	5.427399718	Excellent
S-1	28	23	9.246681001	Excellent
B-3	54	13	10.07945662	Excellent
B-4	56	15	12.06088826	Excellent
B-5	61	11	9.63435241	Excellent
S-2	32	21	9.64871061	Excellent
S-3	36	19	9.821009014	Excellent
S-4	25	20	7.179100156	Excellent
B-6	41	04	2.354744851	Excellent
B-7	46	08	5.283817715	Excellent

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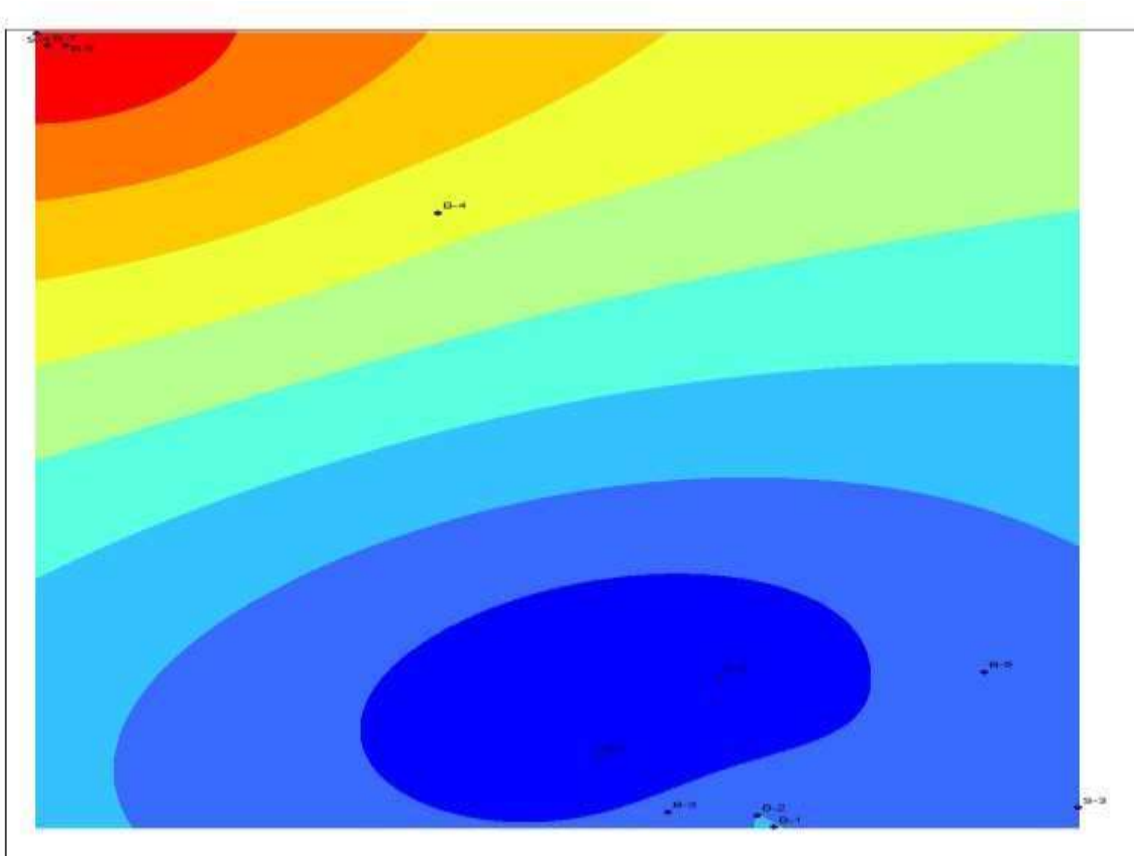

Figure 2(a): Arc GIS-based spatial distribution of K+ ions in ppm in the Bhopal region

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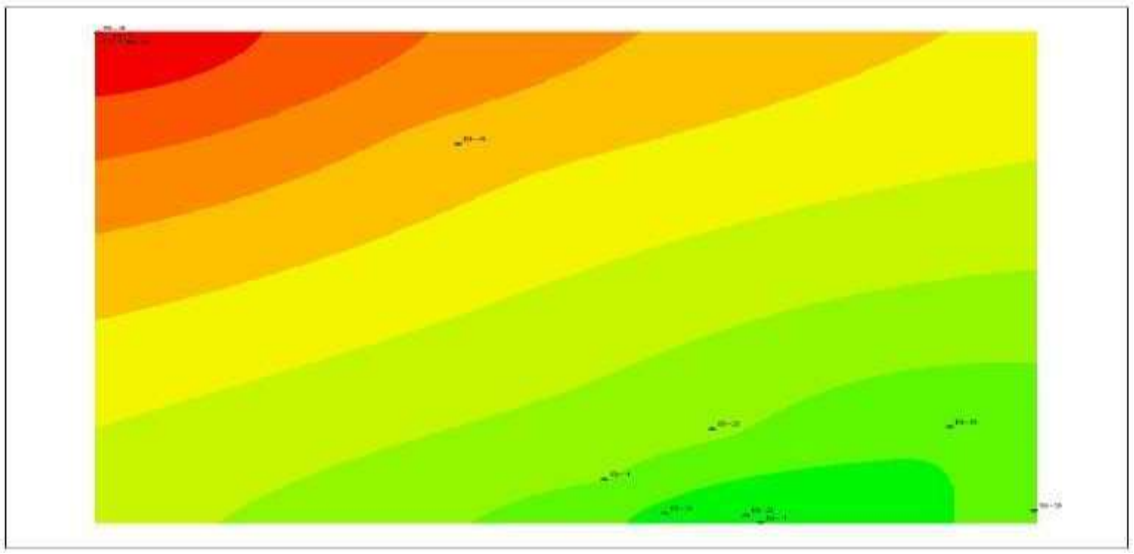

Figure 2(b): Spatial distribution of Na+ ions in ppm in the Bhopal region using Arc GIS

The findings suggest that activities of the residents of Bhopal district such as the excessive application of water softeners, pesticides, deep penetration of used wastewater in should be restricted in the Bhopal region, despite the fact that Tested water samples have Na and K concentrations that are well within allowable bounds and safe for ingestion by humans.

CONCLUSIONS

The examination of Na+ and K+ ions found in 11 water samples obtained from surface and subsurface water bodies in and around the Bhopal region revealed varied cation concentrations. The cation concentrations in the Bhopal region's water bodies are safe for industrial, agricultural, and drinking purposes. The water at the Bhanpur PMAY construction site, which is adjacent to the Bhopal-Vidisha Highway, has the lowest concentration of Na+ and K+. Despite being a less accurate analytical approach for metal cations measurement, flame photometry has greater efficiency for identifying Na+ and K+ ions. Human activity around the Bhopal district must also be maintained under limits in order to keep the K+ ion content within permissible limit. Around PMAY Bhanpur Based on the amount of sodium and potassium ions present, construction site water may be determined to be the most suitable for everyday use. From the perspective of the salt and potassium amounts in it, all water bodies' water is generally acceptable for human consumption and use. Therefore, when dumping pollutants individuals should use

prudence. We need to reduce synthetic inputs into the food chain and improve waste management if we want to leave a planet that can support next generations.

Nomenclature

WQI - Water Quality Index
Na+ - (Sodium) Concentration
K+ - (Potassium) Concentration
GIS- Geographic information system
AAS- Atomic Absorption Spectroscopy
ICPAES - Inductively Coupled Plasma Atomic Emission Spectroscopy
°C - Celsius
(mg/l) - Milligrams Per Liter

DECLARATIONS

Conflict of interest: Each author affirms that they have no competing interests, led by the corresponding author.

No research involving people, animals, or patients was done by any of the authors for this publication, therefore it has ethical approval.

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