

Ionic Ratio Analysis for Understanding Geochemical Controls on The Water Quality of Wagholi Lake, Amravati District, Maharashtra

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Abstract—The analysis of ionic ratios serves as an effective approach for interpreting the hydrochemical mechanisms that influence surface water quality. In this investigation, major ionic ratios were examined in water samples obtained from Wagholi Lake in the Amravati District of Maharashtra to evaluate geochemical processes and determine the water's suitability for domestic and agricultural use. Ratios such as $\text{Ca}^{2+}/\text{Mg}^{2+}$, Na^+/Cl^- , $\text{Na}^+/\text{Ca}^{2+}$, and $\text{Cl}^-/\text{HCO}_3^-$ were calculated and interpreted using established hydrochemical indices. The results demonstrate that the chemical composition of the lake water is controlled by both natural geological interactions and human activities within the surrounding catchment. The prevalence of alkaline earth elements over alkali metals, together with the dominance of bicarbonate over chloride, reflects carbonate mineral weathering as the primary factor governing water chemistry. Based on these ionic relationships, the lake water exhibits moderate suitability for irrigation, emphasizing the importance of continuous monitoring to maintain its safe and sustainable use. This study highlights the role of ionic ratio evaluation as a reliable tool for hydrochemical assessment and long-term water resource management, with specific reference to Wagholi Lake, Amravati District, Maharashtra.

Index Terms—Ionic ratios, Geochemical Controls, Wagholi lake.

I. INTRODUCTION:

Groundwater chemistry is primarily influenced by geological setting, climate, and human activities (Domenico & Schwartz, 1998; Hem, 1985). Ionic ratios are widely applied to identify weathering processes and sources of dissolved ions in natural waters (Gibbs, 1970; Subramani et al., 2010). Groundwater quality assessment through ionic ratios

provides insights into geochemical processes, rock–water interaction, and anthropogenic impacts (Hem, 1985; Gibbs, 1970). In the study area, hydrogeochemical evaluation reveals dominance of silicate and carbonate weathering with minor evaporite influence (Roy et al., 2020; Nair, 2021). Recent studies emphasize the importance of ionic ratios in distinguishing natural versus anthropogenic inputs to groundwater (Goyal et al., 2023; Bakshe et al., 2024; Selvam, 2025). Such evaluation not only helps in hydrochemical characterization but also determines irrigation and drinking suitability of groundwater resources (Ramachandran, 2025; Giri et al., 2025).

Recent hydrogeochemical studies in India highlight carbonate and silicate weathering as dominant contributors to groundwater quality (Roy et al., 2020; Nair, 2021).

II. MATERIALS AND METHODS:

Water samples were collected from Wagholi Lake, Amravati District (Maharashtra), and analyzed for major cations and anions following APHA (2017) standard protocols. Ionic ratios such as $\text{Ca}^{2+}/\text{Mg}^{2+}$, Na^+/Cl^- , and $\text{HCO}_3^-/\text{Cl}^-$ were calculated to evaluate hydrogeochemical processes (Shunmugam, 2022).

III. RESULTS AND DISCUSSION:

The Na^+/Cl^- ratio close to unity suggests negligible halite dissolution and dominance of silicate weathering (Gibbs, 1970; Roy et al., 2020). The $\text{Ca}^{2+}/\text{Mg}^{2+}$ ratio (~1–1.6) indicates dolomitic limestone dissolution (Hem, 1985; Subramani et al., 2010).

Similarly, the $\text{HCO}_3^-/\text{Cl}^-$ ratio points toward a carbonate weathering source, with minimal anthropogenic influence (Nair, 2021; Goyal et al., 2023; Ramachandran, 2025). Slightly elevated sulfate concentrations may reflect gypsum dissolution or fertilizer leaching (Bakshe et al., 2024). Overall, ionic ratios confirm that carbonate and silicate weathering dominate water chemistry, while anthropogenic contributions are minor (Selvam, 2025; Feng et al., 2025).

Ca+Mg vs HCO_3+SO_4

The plots of the sample’s values of the Ca+Mg vs HCO_3+SO_4 scatter diagram show that the majority of the samples fall above the equiline, indicating excess of Ca+Mg values (Fig. 1). The dominance of calcium and magnesium indicates carbonate weathering due the presence of anthropogenic activity like thermal power industrial Westwater. thereby resulting in a reduction of calcium and magnesium concentration in the groundwater (Datta and Tyagi, 1996). The points located above the equiline, which indicate an excess of Ca+Mg, are interpreted as products of carbonate weathering (Lakshmanan et al., 2003).

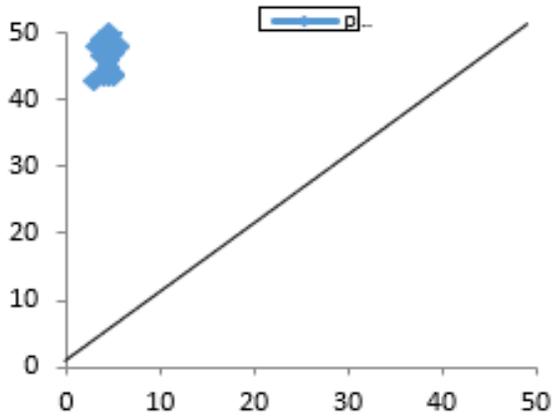


Fig 1: Ca+Mg vs HCO_3+SO_4 scatter diagram

Na vs Cl

The scatter plot shows that most samples lie below the equiline (Fig. 2), indicating that sodium concentrations exceed those of chloride, which is characteristic of silicate weathering (Lakshmanan et al., 2003). Conversely, samples plotting above the equiline exhibit a high Na/Cl ratio. This elevated ratio is likely governed by water–rock interactions, particularly the weathering of feldspar minerals (Zhu et al., 2008).

The Na–Cl scatter diagram is also used to assess the contribution of silicate weathering. Halite dissolution releases sodium and typically maintains the Na–Cl equiline (1:1). When Na concentrations fall below those of Cl, it indicates limited or no contribution from silicate weathering (Lakshmanan et al., 2003).

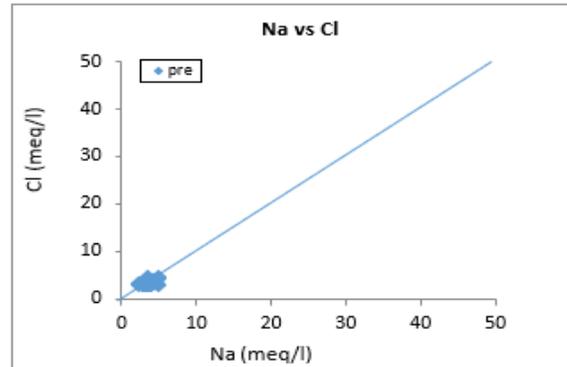


Fig 2: Na vs Cl scatter diagram

Na vs HCO_3

The plots of the present data show that HCO_3 concentrations are consistently higher than those of Na (Fig. 3). The Na– HCO_3 relationship is also an indicator of silicate weathering. According to Lakshmanan et al. (2003), elevated HCO_3 relative to Na reflects the dominance of silicate weathering, which occurs due to the reduction of sodium concentrations in groundwater through ion-exchange processes.

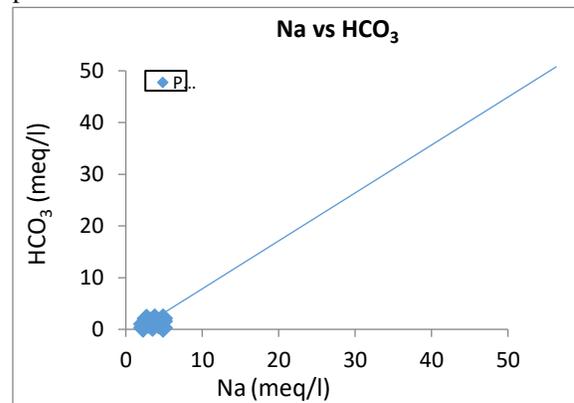


Fig 3: Na vs HCO_3 scatter diagram

IV. CONCLUSION:

The ionic ratio approach successfully identified carbonate and silicate weathering as the main contributors to the hydrochemistry of Wagholi Lake. This method also provides insights into anthropogenic

pressures on water resources Continuous monitoring is essential to ensure long-term sustainability of water quality

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Tables:

Table 1: Values in mg/lit.

Ca	Mg	Na	K	Cl	SO ₄	CO ₃	HCO ₃
128	504.896	62	12	108	162	24	104
129.6	516.5072	52	10	110	133	32	52
120	506.84	88	8	106	121	24	76
124.8	521.6736	105	11	110	134	16	76
115.2	512.0064	112	12	104	131	16	80
112	500.784	109	10	110	133	24	80
108.8	493.5616	70	7	106	156	32	64
112	460.784	73	24	110	122	24	68
116.8	499.6176	70	6	100	130	32	68
110.4	501.1728	70	4	100	124	32	60
132.8	487.7296	82	12	98	158	24	88
136	498.952	92	24	100	163	32	72

128	496.896	90	18	110	149	40	80
110.4	493.1728	86	14	104	157	24	56
102.4	519.1168	87	14	106	166	24	108
110.4	513.1728	84	16	110	152	40	52
112	516.784	80	13	108	129	48	24
108.8	525.5616	74	12	106	156	40	52
96	548.672	69	10	112	167	40	52
96	468.672	68	10	112	164	24	76
112	464.784	78	8	160	167	64	80
128	552.896	97	26	128	184	56	56
128	468.896	112	27	150	203	48	16
112	460.784	99	26	140	167	32	48
108.8	473.5616	100	30	126	195	24	80
112	532.784	98	32	140	174	104	36
128	536.896	114	29	150	190	56	16
112	532.784	116	30	130	185	80	40
120	474.84	115	30	128	216	40	48
99.2	455.8944	110	20	130	163	40	24
144	525.008	112	21	130	168	32	132
208	645.456	134	32	140	200	8	128
196.8	652.1776	140	38	136	183	8	104
304	606.128	66	25	150	164	8	152
200	431.4	86	34	100	168	8	104