








Vanishing waters: water chemistry of temporary rock pools of the Western Ghats, India

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ABSTRACT

The freshwater rockpools support high endemic biodiversity but are poorly studied habitats in the Western Ghats biodiversity hotspot. These freshwater rock pools are situated on outcrops at various elevations in the Western Ghats and are composed of different bedrocks such as laterite and basalt. We aimed to analyze the water quality, geographical position based differences in the water chemistry and the role of bedrock in determining the water chemistry of the rock pools. Our study showed a wide range of water quality variables such as pH, conductivity, and ionic contents that attributed to the natural variation. We observed a drastic variation in the anions and cations at low elevation pools. Rock type and precipitation are influencing the ionic concentration; for example, Calcium and Bromide could be attributed to the seasonal precipitation and geomorphology. This documentation of physicochemical properties of the Western Ghats rock pools can form a baseline for further detailed studies.

Key words: anions, Basalt Mesa, cations, ferricretes, rockpools, water quality

HIGHLIGHTS

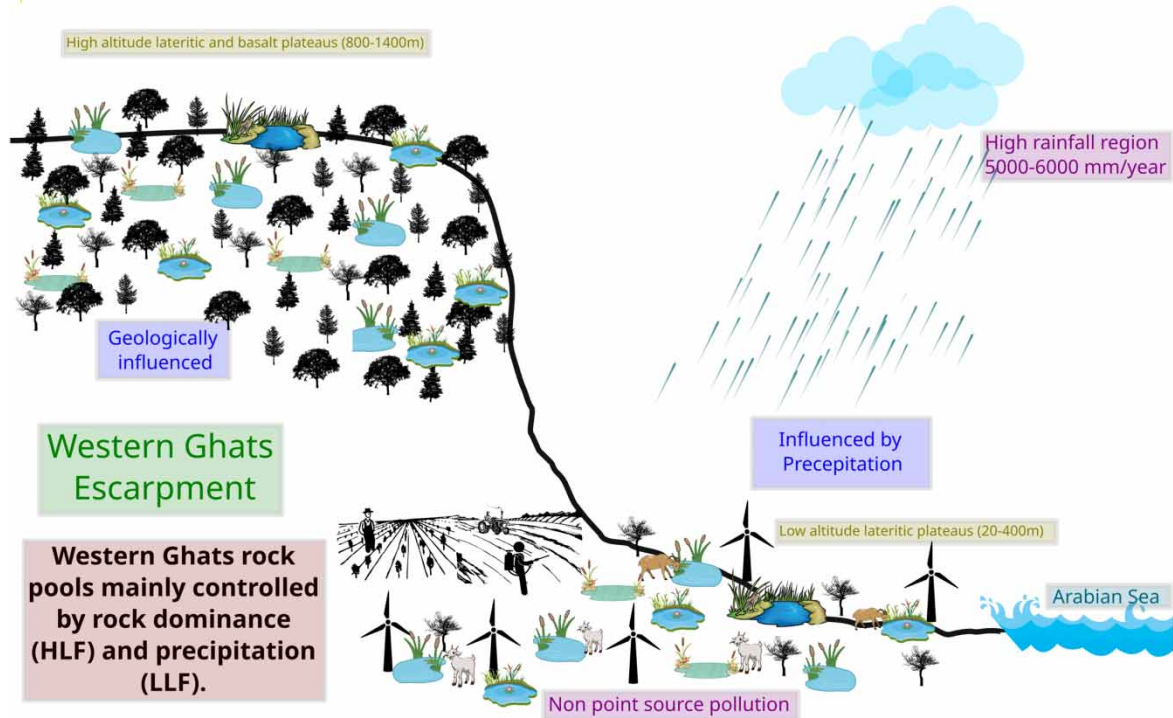
- The water quality across rock outcrops of Western Ghats is documented.
- 80 different rockpools show high variation in the physicochemical composition.
- Water quality of the rock outcrops is suitable for supporting aquatic life.
- Rock type and precipitation influence the ionic concentration of water.

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GRAPHICAL ABSTRACT



Water Quality of Lateritic plateaus



INTRODUCTION

Ecologists and environmental specialists are fascinated to understand the functions, services, reliability, and sustainability of different ecosystems. Different kinds of aquatic and terrestrial habitats furnish different ecosystem services and functions. Various freshwater bodies such as rivers, ponds, lakes, and pools are present on the continental lands. However, due to anthropological activities, these freshwater bodies are tarnished with chemicals and heavy metals. Being a primary source of water for domestic, agricultural, and industrial activities, it is essential to quantify the chemicals of freshwater bodies. Temporary water bodies are aquatic habitats that hold water periodically and experience cyclic wet and dry phases (Williams 2006). Freshwater rockpools are temporary water bodies with surface depressions on rocky areas that hold freshwater (Brendonck *et al.* 2010). The formation of rock pools results from weathering, which creates a depression where the water is accumulated (Campbell 1997). The weathering rate and pattern dictate the size and shape of the rock pools (Campbell 1997). Rockpools receive water at different times of the year, depending upon their geographical position and seasonal rainfall (Deil 2005). However, rain-fed rock pools are typical of freshwater rock pools. Commonly, rockpools occur on rock outcrops all over the world; however, they are abundant in arid and semi-arid regions (Williams 2006), made up of various bedrocks such as granite, sandstone, and limestone (Disney 1975; Scholnick 1994; Krieger *et al.* 2000; Pinder *et al.* 2000; Chan *et al.* 2005). Seasonal water availability, resulting in cyclic phases of inundation and drought, are characteristic features of rock outcrops (Porembski & Barthlott 2000). Hence, the rock pools on such outcrops hold water seasonally and dry during other times (Krieger *et al.* 2000).

The abiotic elements such as the rock pool's physical and chemical parameters play a crucial role in supporting diverse life forms. Every freshwater body has distinct physicochemical characteristics, determined mainly by climatic, geomorphological, and geochemical conditions (Chapman 1996). The aquatic ecosystem's water quality will provide essential information regarding available resources to support various life forms in that ecosystem. Multiple government and nongovernmental agencies assess freshwater using the Water Quality Index (Tyagi *et al.* 2013). Water Quality Index is a tool to examine water quality and whether it is potable or suitable for industrial use. Water quality assessments for various aquatic systems are conducted regularly all over the world. However,

recently there has been increasing attention to rock pools as the studies on extreme habitats such as rock outcrops are increasing (Porembski & Barthlott 2000) across the world. Studies on rock pools of granite outcrops in Australia and the USA (Pinder *et al.* 2000; Chan *et al.* 2005; Jocque *et al.* 2007) as well as sandstone outcrops in the USA (Scholnick 1994; Chan *et al.* 2005) are a few of the works reporting the role of water quality in determining the biodiversity (Table 1). India is home to different rock outcrops such as plateaus of laterite (ferricrete), basalt (basalt mesa), cliffs, and inselbergs. The studies on Indian rock outcrops are still in the primary stage, mainly focusing on documentation of various taxa occurring on outcrops (Chikane & Bhosale 2012; Watve 2013); and a few ecological studies (Porembski & Watve 2005; Thorpe *et al.* 2018). Only a few studies attempted to document the biodiversity of the rock pools of the Western Ghats. Studies reporting the plant species (Prمود *et al.* 2014) and microinvertebrates (Padhye & Victor 2015; Paripatyadar *et al.* 2021) from the rock pools of selected Western Ghats outcrops did not present any water chemistry results and its relation to biodiversity. Although there are studies on water quality assessment from other freshwater aquatic habitats of India (Jain *et al.* 1996; Sreenivasan *et al.* 1997; Moundiotiya *et al.* 2004; Chardhry *et al.* 2013), there are no studies from the rock pools.

Table 1 | Summary of the work done on rock pools on granitic inselbergs and sandstone outcrops from other parts of the world reporting various water quality parameters

Citation	Focus of study	Location	No. of pools	Water quality
Pinder <i>et al.</i> (2000)	Aquatic invertebrates	South-Western Australia	9	pH, Total N, Total P, Alkalinity, Hardness, Turbidity, Chlorophyll, Si, Na, Ca, K, Mg, Mn, Cl, SO ₄ , NO ₃ ⁻ , NO ₂ , Carbonate+ Bicarbonate
Scholnick (1994)	Seasonal and diurnal variation in rock pools	South-eastern Utah	4	pH, Temperature, Oxygen
Chan <i>et al.</i> (2005)	Aquatic invertebrates, physical, chemical characteristics of water	Colorado	28	pH, Conductivity, Si, Fe, Mn, Ca, Mg, Na, K, F, Cl, NO ₂ -N, NO ₃ -N, Br, PO ₄ and SO ₄
Brendonck <i>et al.</i> (2000)	Branchiopods species ecology, water quality	South Africa, Botswana	30	pH, Conductivity, Temperature
Hamer & Martens (1998)	Diversity of large Branchiopoda	Drakensberg, South Africa	90	pH, Conductivity, Temperature
Baron <i>et al.</i> (1998)	Aquatic invertebrates, physical, chemical characteristics of water	Capitol Reef national park, Utah	20	pH, Conductivity, Alkalinity, Si, Ca, Mg, Na, K, NH ₃ , Cl, PO ₄ and SO ₄ , Dissolved organic carbon

In the present investigation, we assessed the water quality of 80 rock pools from 29 rock outcrops of the Western Ghats, (a) to investigate the role of bedrock in determining the chemical composition of water from the rock pools, (b) to explore whether there are any changes in water quality parameters based on geographical position, and (c) to examine the dominant factor influencing the water chemistry in the rock pools of Western Ghats.

MATERIALS AND METHODS

Study area

The Western Ghats (henceforth referred as WG) is an approximately 1,600 km long mountain range parallel to India's west coast. WG is one of the 36 global biodiversity hotspots (Noss *et al.* 2015) and one of the three most threatened hotspots (Cincotta *et al.* 2000) by human population and activity. Though a predominant rock type in WG, a million-year-old basalt has transformed into laterite due to the physical and chemical weathering on the hilltops. Moreover, the laterite cover has eroded in most places and remains only as caps on the mountain between 14° and 18°N of the WG escarpment (Widdowson & Cox 1996). These flat-topped laterite outcrops occurring at high elevations are known as High-Level Ferricretes (HLF), while at low elevations next to the west coast, they are known as Low-Level Ferricretes (LLF). North of 18° latitude on the high altitudes, the outcrops have further eroded, exposing the parent basalt rock (Ollier & Sheth 2008), and are known as Basalt Mesa (BM).

High-Level Ferricretes (HLF) are geographically separated from each other and the surrounding areas. LLF is more or less continuous from Maharashtra (16°N) to Northern Kerala (12°N), interspersed with tree pockets, agricultural lands, and human settlements. The microclimatic conditions of these regions vary from almost xeric in the summer and winter (October–May) to inundated during the monsoon (June–September) (Watve 2007; Shigwan *et al.* 2020). Rockpools get filled and often flooded during the monsoon (June–September) and are primarily dry during other times of the year. Figure 1 shows the annual precipitation and annual temperature at study sites.

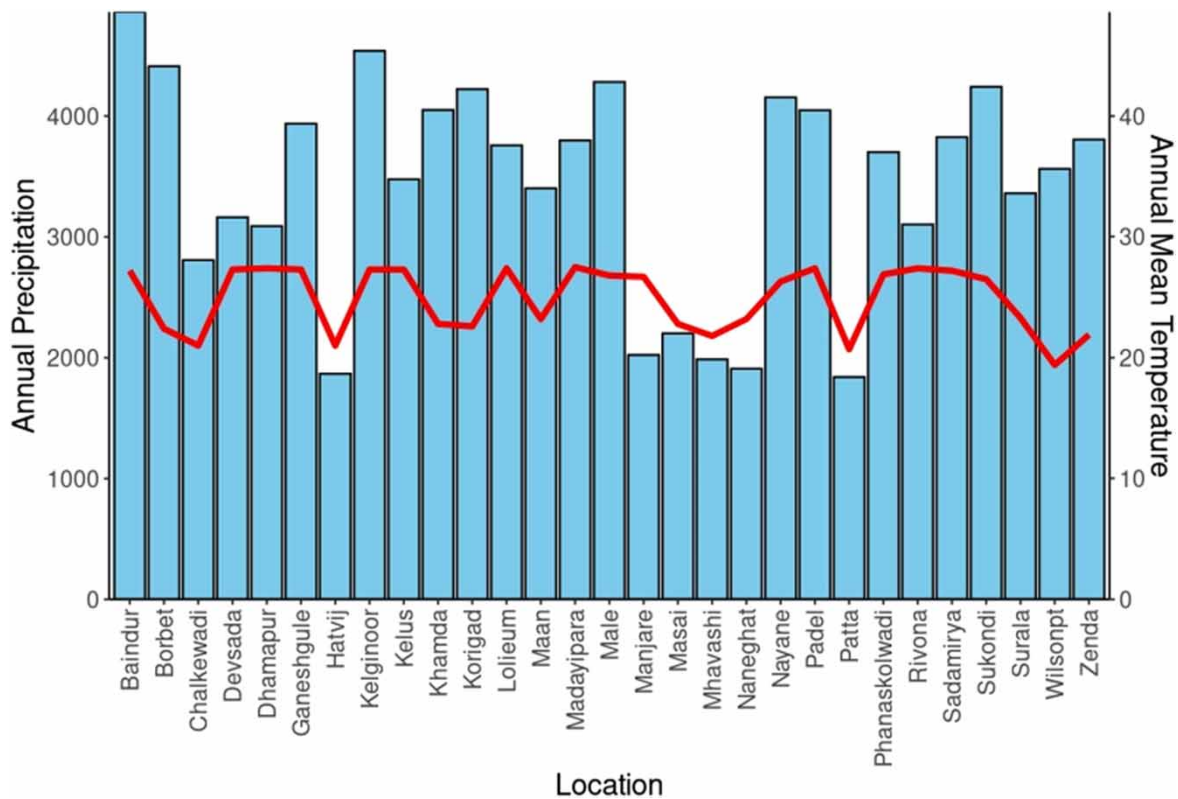


Figure 1 | Annual precipitation and annual temperature at study sites in the Western Ghats.

Sample collection

The rock pools get filled with water during the monsoon and post-monsoon season (August–October). We collected water samples from twenty-three outcrops in Maharashtra, three outcrops in Goa, two outcrops in Karnataka, and one outcrop from Kerala during August–September of 2017–2018 (Figure 2). Among 29 outcrops, 24 were lateritic outcrops (15 LLF and 9 HLF), while five were basalt outcrops (BM). From these outcrops, we surveyed a total of 80 pools, 15 BM, 24 HLF, and 41 LLF pools. We collected a water sample of approximately 300 ml, once from each rock pool (natural as well as stone quarried pools) in clean single use Polyethylene cans. We stored these cans in the icebox under dark conditions to prevent degradation of ionic contents, and the water was used for further analysis. We measured the maximum length and maximum breadth for each rock pool using a measuring tape to calculate the approximate area of the pond. We also measured water depth at three to five random points for each rock pool and calculated the average depth. For each rockpool, we recorded geographical coordinates and elevation readings using eTrex® 30x (Garmin®, Kansas, USA). We measured water quality on-field for parameters such as pH, conductivity, temperature, and Dissolved Oxygen (DO) using an HQ40D portable multi-parameter (Hach, Loveland, Colorado, USA). Further, we measured nitrate and phosphate within 24 hours of collection, using a portable Hach spectrophotometer DR1900 (Hach, Loveland, Colorado, USA) and Hach chemicals (NitraVer®3 Nitrate and NitraVer®6; PhosVer®3 Phosphate).

Laboratory analysis

We brought the samples to the laboratory and stored them at -20°C . We centrifuged the water samples at 5,000 rpm for 10 min and filtered them through a $0.2\ \mu\text{m}$ syringe filter to remove the suspended particles. The

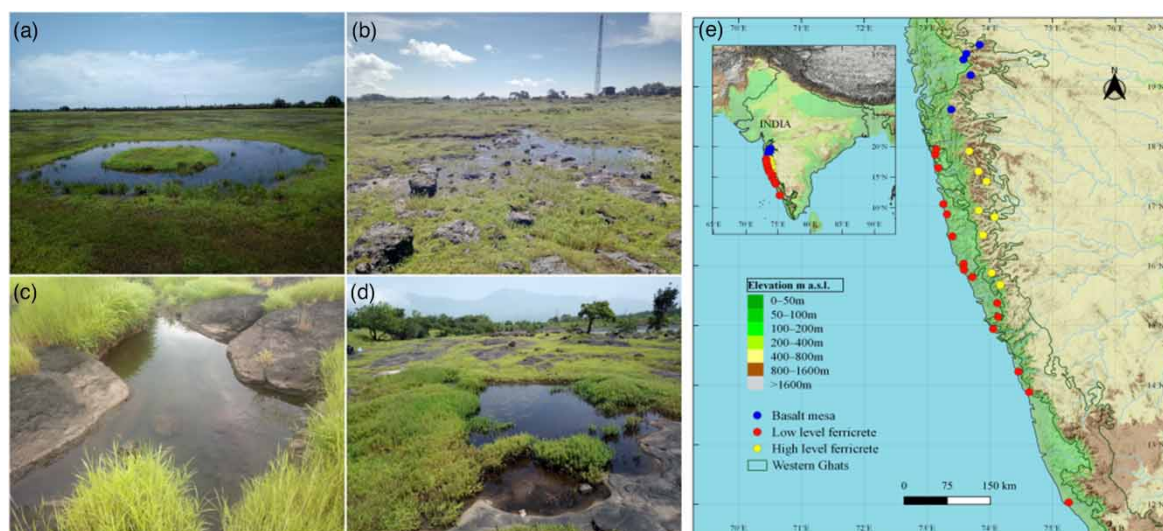


Figure 2 | Rockpools on (a) Low-level Ferricrete; (b) High-Level Ferricrete; (c) and (d) Basal Mesa; (e) map showing the location of the sampled plateaus across the Central and Northern Western Ghats.

anion and cation present in the samples were determined using ion chromatography (882 Compact IC plus, Metrohm). For confirmation of anions present in the samples, we used a multielement anion standards solution (Sigma-Aldrich) F^- , Cl^- , Br^{2-} , NO_3^- , PO_4^{3-} , and SO_4^{2-} of 10 ppm. Samples were analyzed using Metrosep A supp 5 -250/4.0 column. We prepared the mobile phase using 1 mM $NaHCO_3$, 3.2 mM Na_2CO_3 , and 10% acetonitrile (organic suppressor). The suppressor solution composed of 50 mM H_2SO_4 and 50 mM Oxalic acid was used. The eluent flow rate of 0.5 ml/min was set, a 20 μ l sample was injected, and the samples were detected using a conductivity detector.

Similarly, for confirmation of cations present in the samples, multielement cation standard solution (Sigma-Aldrich) Li^+ , Na^+ , K^+ , Mg^{2+} , and Ca^{2+} of 10 ppm of each ion was used. Samples were analyzed using Metrosep C 4- 150/4.0 column. The mobile phase consisted of 1.7 mM HNO_3 , 0.7 mM dipicolinic acid, and 10% acetonitrile. Acetonitrile was used to suppress the conductivity due to the organic content present in the sample. The eluent flow rate of 0.7 ml/min was set, a 20 μ l sample was injected, and samples were detected using a conductivity detector. The MagIC Net™ software was used for data acquisition and determination of the concentration of the ions.

Data analysis

We prepared a map with the help of QGIS (version 2.18.28) using the geographical coordinates of the sampled pools to visualize the geographical spread of the study area. We used Inkscape 0.92.3 (available from: <http://www.inkscape.org>) to prepare a photo plate showing the study area and rock pool pictures.

To observe the general spread of the data, we prepared a histogram. To understand the pattern of ionic content across types of outcrops, we prepared boxplots in R (version 3.6.2) using the package ggplot2 (Wickham 2016). For graphical comparison of Ca, Mg, and Na + K composition, we plotted the Ternary graph using the package ggtern (Hamilton & Ferry 2018) in R (version 3.6.2). We also prepared a Gibbs plot using SigmaPlot 12.5 (Systat software, Germany) to understand how water chemistry is related to lithological characteristics.

RESULTS AND DISCUSSION

Physical and chemical properties of the rock pools

We surveyed 80 rock pools located on twenty-nine rock outcrops in the Western Ghats in the present study. The size of the pools varied across rock outcrops from 0.5 sq. m to 780 sq. m, and average depth ranged from 1 to 66 cm. Some of the pools showed accumulation of a high amount of organic debris, whereas some pools showed hardly any organic debris. Most of the pools (72) contained vegetation dominated by *Eriocaulon* L., *Rotala* L., and *Cyperus* L., while eight pools did not have vegetation.

On-field measurements such as pH, conductivity and temperature varied across rock pools (Table 2). pH ranged from 5.41 to 9.75 with a mean pH of 7.11 ± 0.89 ; Phanaskolwadi (LLF) had the most acidic pH (5.41), whereas a Manjare (BM) had the most alkaline pH (9.75) among the sampled pools (Figure 3). Rock pools of the Western Ghats show acidic pH observed for specialized ecosystems like *Myristica* swamps

Table 2 | Statistics of physicochemical parameters, major ions, World Health Organization (WHO 2017) and Bureau of Indian Standards (BIS 2012) for drinking waters of the study area

	No. of pools	Min	Max	Range	Mean \pm SD	Median	WHO standard (2017)	BIS standard (2012)
pH	80	5.41	9.75	4.34	7.11 ± 0.89	6.99	6.5–8.5	6.5–8.5
EC (μ S/cm)	80	18.00	897.00	879.00	122.21 ± 148.94	71.50	1,500	500–1,500
TDS (mgL^{-1})	80	2.15	448.50	446.35	60.52 ± 74.75	35.45	600–1,000	500–2,000
Temp ($^{\circ}\text{C}$)	80	23.30	36.90	13.60	30.29 ± 3.54	29.60	–	–
NO_3 (mgL^{-1})	80	0.00	3.10	3.10	0.05 ± 0.35	0.00	50	45
PO_4 (mgL^{-1})	80	0.00	27.40	27.40	1.92 ± 4.65	0.28	0.1–1	0.5–1
DO (mgL^{-1})	47	2.00	18.41	16.41	7.44 ± 2.44	7.56	5	4–6
Na^+ (mgL^{-1})	80	0.12	53.93	53.81	7.45 ± 10.92	2.46	50	200
NH_4^+ (mgL^{-1})	80	0.00	5.82	5.82	0.19 ± 0.74	0.00	0.2	–
K^+ (mgL^{-1})	80	0.00	13.28	13.28	0.85 ± 2.21	0.18	12	–
Ca^{2+} (mgL^{-1})	80	0.14	17.03	16.89	3.12 ± 2.76	2.14	75	75–200
Mg^{2+} (mgL^{-1})	80	0.00	8.89	8.89	1.30 ± 1.42	0.78	50	30–100
F^- (mgL^{-1})	80	0.00	4.68	4.68	0.22 ± 0.67	0.00	1.5	1.0–1.5
Cl^- (mgL^{-1})	80	0.00	93.09	93.09	6.22 ± 15.35	2.09	250	250–600
Br^- (mgL^{-1})	80	0.00	18.54	18.54	0.79 ± 2.32	0.00	0.5–1.0	–
SO_4 (mgL^{-1})	80	0.00	105.28	105.28	6.13 ± 16.99	1.06	500	200–400

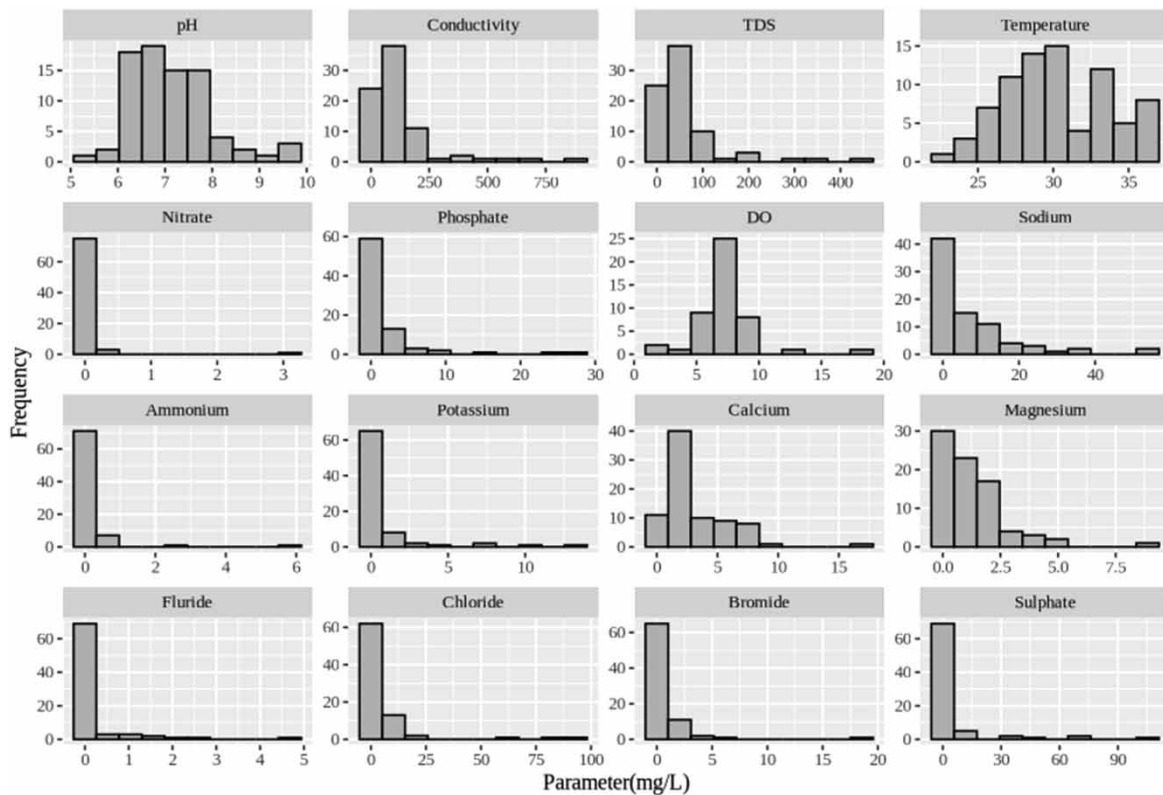


Figure 3 | Range distribution of various chemical parameters of rock pools.

(Ranganathan *et al.* 2021) as well as highly alkaline pH usually found in the meteor crater at Lonar, Maharashtra (Thakker & Ranade 2002). Specific conductivity varied from 18 to 897 $\mu\text{S cm}^{-1}$, with the minimum conductivity (18 $\mu\text{S cm}^{-1}$) recorded from Zenda (HLF) and the maximum (897 $\mu\text{S cm}^{-1}$) from Kelus (LLF) with a mean of $122.21 \pm 148.94 \mu\text{S cm}^{-1}$ (Figure 3). Conductivity of the distilled water produced in a laboratory is in the range 0.5–3 $\mu\text{S cm}^{-1}$ whereas, that of domestic wastewaters is between 50 and 1,500 $\mu\text{S cm}^{-1}$ (APHA 1912). Dissolved oxygen levels ranged from 2 to 18.41 mgL^{-1} with a mean of $7.44 \pm 2.44 \text{mgL}^{-1}$. Dissolved oxygen levels from rock pool of South Africa ranges from 3.5 to 9.6 mgL^{-1} (De Vries 1996). Whereas, for river systems generally ranged from 1.86 to 12.28 mgL^{-1} (Tokatli *et al.* 2020; Tokatli & Varol 2021).

The ionic concentrations of Chloride and Calcium ranged between 0 and 10 mgL^{-1} . Only Kelginoor pools (LLF) showed Chloride concentrations between 60 and 93.09 mgL^{-1} . Further, the Calcium concentration in a rock pool at Manjare (BM) was 17.03 mgL^{-1} . Bromide concentration was less than 5 mgL^{-1} in all the rock pools except at Padel (LLF), 18.54 mgL^{-1} . Except for Chalkewadi (HLF), Kelginoor (LLF), and Sadamirya (LLF) outcrops, potassium concentration ranged between 0 and 1 mgL^{-1} . Manjare outcrop (BM) recorded a high magnesium ion concentration (8.89 mgL^{-1}), while in other outcrops, the values ranged between 0 and 5 mgL^{-1} . As compared to other ions, Sulphate showed an overall higher concentration and a more extensive range (0–105 mgL^{-1}). Calcium concentration, except Manjare, was lower than Sandstone outcrops (23.4 mgL^{-1}) while other ion concentrations were higher for Western Ghats rock pools (Baron *et al.* 1998; Chan *et al.* 2005).

The physicochemical parameters and most of the ion concentrations (other than DO, NH_4^+ , and Br^-) of the Western Ghats rock pools are below the surface water range as per the WHO standard (2017) and BIS standard (2012) (Table 1).

Comparison of water quality parameters between types of outcrops

A comparison of water parameters between the types of outcrops is explained in Figure 4. The rock pools of LLF ranged from acidic to alkaline pH (5.41–8.7) and had specific conductivity from 26.10 to 897 $\mu\text{S cm}^{-1}$; temperature also showed a wide range in the LLF outcrops. In contrast, the other two groups showed a narrow range of these variables. Water from rock pools on Granitic inselbergs from South Africa and Botswana ranges from highly acidic (pH = 4.3) to highly alkaline (pH = 11.3) (De Vries 1996; Brendonck *et al.* 2000). However, rock

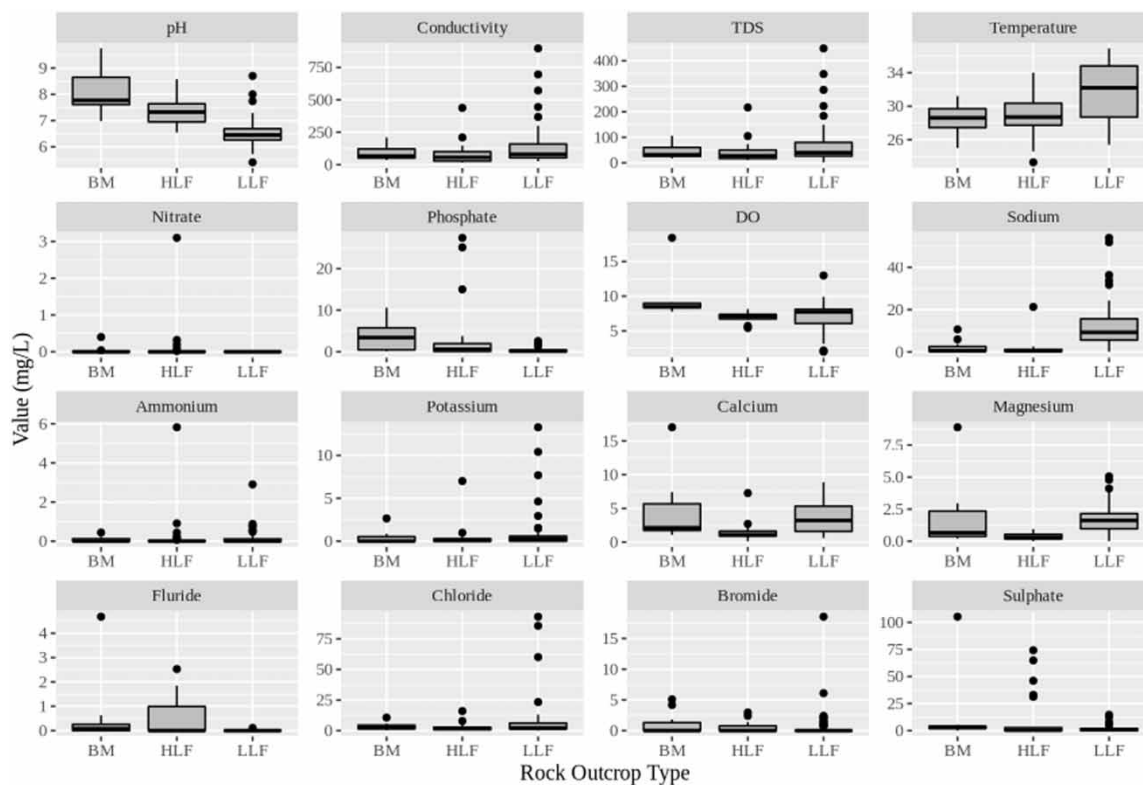


Figure 4 | Boxplots showing various chemical parameters across rock outcrop types. (HLF – High Level Ferricrete, LLF – Low Level Ferricrete, BM – Basalt Mesa).

pools on Sandstone outcrops from the USA are slightly acidic to alkaline (pH = 6.7–10.1) (Chan *et al.* 2005). Western Ghats rock pools are generally slightly acidic (mean pH = 6.89), with few exceptions of acidic (pH = 5.41) as well as highly alkaline (pH = 9.75) pools. Rockpools on LLF were mostly acidic except for a few pools. In contrast, HLF and BM were slightly acidic to alkaline. Frequent rainfalls followed by droughts during the monsoon might result in large fluctuations in pH and conductivity. We observed that rock pools on LLF are more prone to various disturbances such as mining, grazing, and constructions due to their easy accessibility. This might be reflected in few pools having high levels of conductivity. Conductivity values for Granitic and sandstone outcrops generally ranged from 2.3 to 535 $\mu\text{S cm}^{-1}$ (De Vries 1996; Baron *et al.* 1998; Chan *et al.* 2005; Jocque *et al.* 2007). For the Western Ghats, we observed a similar trend except for a few pools exceeding 500 $\mu\text{S cm}^{-1}$. It is observed that rock pools of 5–30 cm depth have a poor buffering capacity (Brendonck *et al.* 2010). The conductivity of greater than 500 $\mu\text{S cm}^{-1}$ could also result from some other sources, such as anthropogenic disturbance.

Nitrate and Phosphate showed low concentrations in the pools of LLF outcrops but were high in the pools of HLF and BM. The ionic concentration of Sodium, Potassium, Chloride, and Bromide showed a broad coverage with higher concentrations in the LLF pools ranging from 0.14 to 53 mgL^{-1} , 0 to 13.28 mgL^{-1} , 0 to 93.09 mgL^{-1} , and 0 to 18.54 mgL^{-1} , respectively. However, HLF and BM pools displayed very low concentrations. In contrast, Calcium, Magnesium, Fluoride, and Sulphate concentrations were high in the BM pools but not in other groups of outcrops. On the HLF outcrops, except for Sulphate and Fluoride, all other ionic concentrations were moderate.

The cationic abundance in the rock pools follows the trend as $\text{Na}^{2+} + \text{K}^{+}$ (65.3%) > Ca^{2+} (24.5%) > Mg^{2+} (10.2%). BM rock pools were mainly rich in Ca^{2+} ions with a contribution >40%, while Mg^{2+} ions account for most of the remaining cationic abundance. HLF rock pools were also Ca^{2+} ion rich (>60%) but combined with Mg^{2+} ions. In most of the LLF rock pools, Na^{+} and K^{+} ions were dominant, while in HLF and BM, Ca^{2+} was dominant. All three types of rock pools were deficient in Mg^{2+} ion (<30%) (Figure 5).

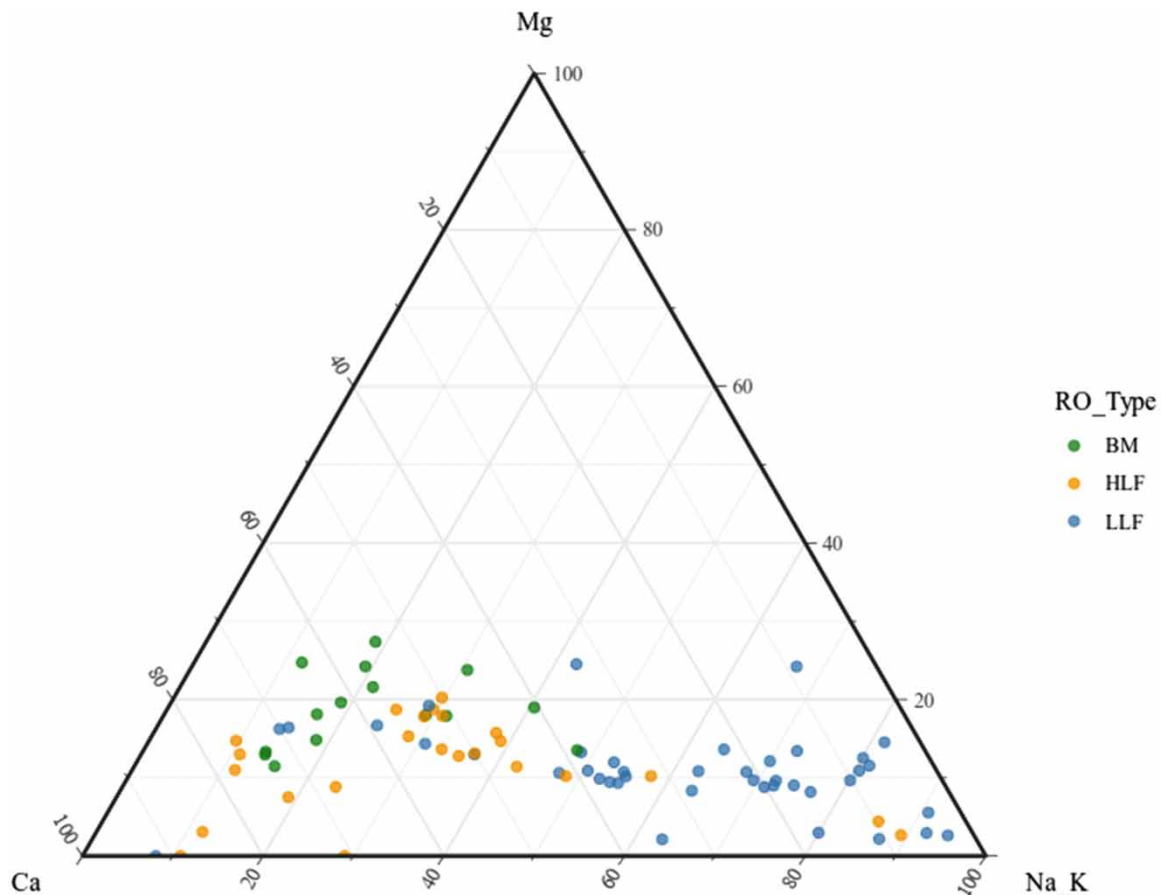


Figure 5 | Ternary graph showing Mg^{2+} , Ca^{2+} , and Na^{2+} ion concentrations across types of rock outcrops. LLF – Low Level Ferricrete, HLF – High Level Ferricrete, BM – Basalt Mesa.

The Gibbs plot is used to analyze the global surface water chemistry with the help of atmospheric precipitation, rock dominance, and the evaporation-crystallization process (Gibbs 1970). Gibbs plots for rock pools of the Western Ghats predicted that the rock weathering and precipitation determined the water chemistry (Figure 6(a) and 6(b)). The water chemistry is controlled by the precipitation for LLF pools and by rock dominance for BM and HLF pools (Figure 6(a) and 6(b)). The rock outcrops in the study area experience high precipitation (Figure 1); however, the amount of precipitation is very high on LLF and could mask the effect of other factors. HLF and BM are geomorphologically different from each other (Ollier & Sheth 2008), therefore rock dominance might play a role in controlling the water chemistry. Studies on groundwater as well as rivers have highlighted importance of rock dominance in controlling the water chemistry (Madhav *et al.* 2018; Marandi & Shand 2018; Pant *et al.* 2018).

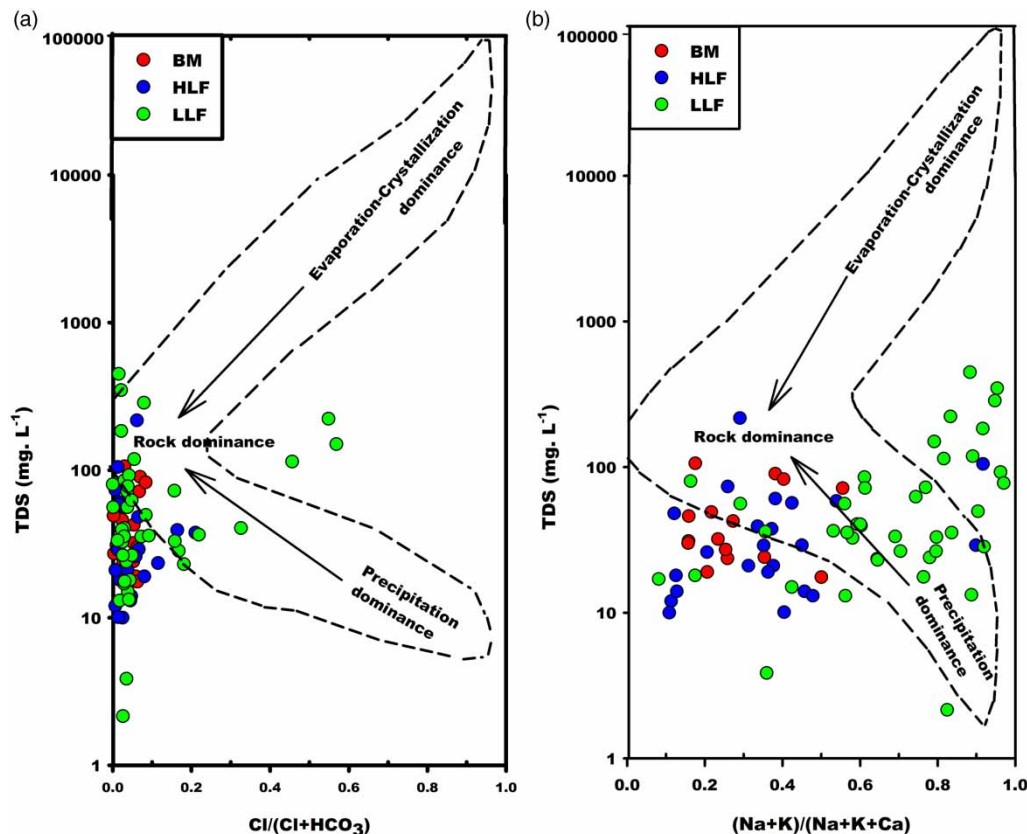


Figure 6 | (a) Gibbs plot showing the influence of precipitation, evapotranspiration, and geological features on anionic contents of the rock pools in the study area. (b) Gibbs plot showing the influence of precipitation, evapotranspiration, and geological features on cationic contents of the rock pools in the study area.

Some physicochemical properties of the rock pools, such as pH and conductivity in the Western Ghats, roughly follow the global pattern (Jocque *et al.* 2010). Other parameters, especially the anions and cations, vary from the pools in the different parts of the world (Jocque *et al.* 2010; Tokatli *et al.* 2020). The local climate, seasonality, base rock, and rainfall patterns could influence water chemistry, which needs a detailed investigation. Rockpools are oligotrophic systems that are highly sensitive to diurnal and seasonal changes. Therefore, the dynamic water chemistry influences the occurrence of various life forms. The water chemistry of the Western Ghats rock pools was mainly controlled by rock dominance and precipitation, resulting in high salinity with a moderate level of conductivity. It seems the water quality of the rock pools is favorable for aquatic life.

Worldwide rock outcrops are facing a variety of anthropogenic pressures, including mining, grazing, construction (Porembski *et al.* 2016); these are observed for the Indian rock outcrops as well (Watve 2013). Rockpools being one of the microhabitats on rock outcrops, are even more vulnerable to the threats and need necessary attention. Agricultural runoff, cattle excretion, and industrial wastewater are some of the sources of

contamination observed in the study area (personal observations). Industrial waters have been shown to change the water chemistry, especially the heavy metal content in the rivers (Tokatli & Varol 2021). Rockpools are a major water source for local settlements (Seine 2000). They contribute to the regional biodiversity by supporting many rare and endemic taxa (Pinder *et al.* 2000; Jocque *et al.* 2007). Diversity studies on rock pools of the Western Ghats have documented many rare as well as novel species of plants (Gaikwad *et al.* 2014; Chandore *et al.* 2016; Lekhak & Yadav 2017) and small invertebrates (Rogers & Padhye 2014; Shinde *et al.* 2014). In these aspects, our study can essentially form the baseline for future investigations focusing on the temporal, specifically diurnal variations.

CONCLUSION

The current study is a first attempt to document the water quality across rock outcrops of Western Ghats and compare the geological and geographical features. Water quality assessment showed that the measurements are comparable with the rock pools from the other parts of the world and suitable for supporting aquatic life. Further studies exploring the biodiversity of the Western Ghats rock pools and their interactions with water parameters would help better understand these habitats.

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AUTHORS' CONTRIBUTIONS

MD and KB formulated the questions. AK, BS, SV, and SR carried out the fieldwork. AK, BS, and SV, with guidance from PK, carried out the laboratory analysis. AK, SR, with the help of YM, wrote the manuscript. All authors read and commented on the manuscript. MD acquired the funding.

AVAILABILITY OF DATA AND MATERIAL (DATA TRANSPARENCY)

Data is available in the form of a table in the main manuscript.

CODE AVAILABILITY (SOFTWARE APPLICATION OR CUSTOM CODE)

NA.

CONFLICTS OF INTEREST/COMPETING INTERESTS

NA.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

ETHICS APPROVAL

NA.

FUNDING

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