Stable Calcium Isotopic Variability in Groundwater from Coastal Aquifers from the Sundarbans Delta, India

Sourav Ganguly[1], Kousik Das[2], Abhijit Mukherjee[2], and Ramananda Chakrabarti[1]

[1]Indian Institute of Science Bangalore
[2]Indian Institute of Technology Kharagpur

November 22, 2022

Abstract

Coastal aquifers act as a major host of seawater-groundwater interaction and play an important role in modulating the marine elemental budget. Calcium stable isotopes ($\delta^{44/40}$Ca) have been used to identify mass dependent isotope fractionation processes such as carbonate dissolution and precipitation in a range of geological reservoirs that has major implications in constraining global geochemical cycles. However, there is limited Ca isotope data from coastal aquifers globally. Here we report $\delta^{44/40}$Ca values of groundwater collected in 2017-18 from multiple locations and depths from the Bakkhali delta front, Sundarbans, India. The sampling depth varied between 14 m below ground level (m bgl) and 333 m bgl and the salinity of the groundwater samples range from 1-25 ppt. The salinity of the water samples decreases with increasing depth indicating greater seawater incursion from the Bay of Bengal at shallower depths. Variable amounts of mixing of freshwater and seawater is also supported by Sr and Ca concentrations which vary between 1.6-62.8 µmol/l and 0.29-8.92 mmol/l, respectively, and show progressively lower concentrations with depth. The $\delta^{44/40}$Ca values of dissolved phase in groundwater samples (relative to NIST SRM 915a) were measured using a ^{43}Ca-^{48}Ca Double Spike TIMS technique at Centre for Earth Sciences, Indian Institute Science, Bangalore. The $\delta^{44/40}$Ca values of the groundwater samples show significant variability between 1.52-2.28˜0.1$\delta^{44/40}$Ca values higher than modern seawater (˜1.88in deeper groundwater samples, is consistent with higher proportions of freshwater input. Samples showing high $\delta^{44/40}$Ca values are mostly from shallower depths and likely reflect carbonate precipitation which is consistent with high Sr/Ca (˜8.13-12.26) in samples from 30-42 m depth. The high $\delta^{44/40}$Ca in groundwater samples from the Ganges-Brahmaputra delta could explain the high $\delta^{44/40}$Ca values reported in water samples from the Bay of Bengal[1]. [1] Chakrabarti et al., Goldschmidt Boston, 2018 Abstract.

Stable Calcium Isotopic Variability in Groundwater from Coastal Aquifers from the Sundarbans Delta, India

Sourav Ganguly[1], Kousik Das[2], Abhijit Mukherjee[2,3], Ramananda Chakrabarti[1, 4]

[1]Centre for Earth Sciences, Indian Institute of Science, Bangalore, India

[2]School of Environmental Science and Engineering, Indian Institute of Technology, Kharagpur, India

[3]Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur, India

[4]Interdisciplinary Centre for Water Research, Indian Institute of Science, Bangalore, India

1. Introduction, Study Area & Sampling

- Sundarbans is a prograding delta of the Ganges-Brahmaputra riverine system that experiences marine transgression and regression.
- Aquifers in such deltaic settings are major sites of seawater-groundwater interaction; such reservoir-scale interactions have implications for marine elemental budgets
- Calcium is one of the major dissolved ions in seawater and Ca stable isotope ratios ($\delta^{44/40}Ca$) are a reliable tracer of sources of Ca as well as carbonate precipitation-dissolution processes. However, limited Ca isotope data are available for coastal aquifers.
- In this study, depth-bound groundwater samples were collected from multiple observation wells within the Bakkhali delta front covering both **near-shore (A)**, **off-shore (B)**, and **deeper tubewell (TW)** locations in 2017-18 hydrologic years.
- Water samples were collected between 14 and 333 m below ground level (mbgl).

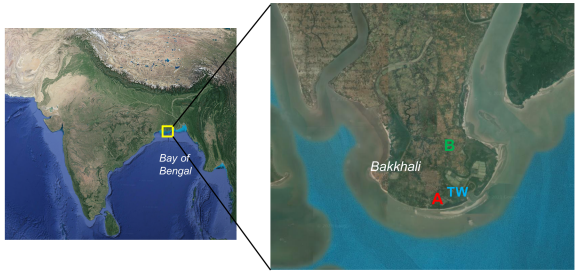

Fig. 1. Google Earth image of the study area located in Sundarbans delta, India

2. Methodology

- Water samples were filtered and stored as per standard protocols for further analysis.
- Cation concentrations were measured using an ICPMS (Thermo iCAP-Q) at IIT Kharagpur (Das et al., 2021).
- $\delta^{44/40}Ca$ values in groundwater samples were measured using a multi-collector TIMS (Thermo Triton Plus) at IISc Bangalore, using a ^{43}Ca-^{48}Ca double spike following established protocols (Mondal & Chakrabarti, 2018).
- All $\delta^{44/40}Ca$ values are reported relative to NIST SRM 915a standard.

3. Results and Discussion

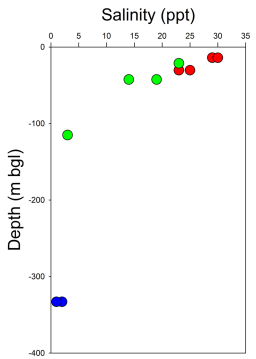

Fig. 2. Salinity (1-30 ppt) of groundwater samples decrease with depth

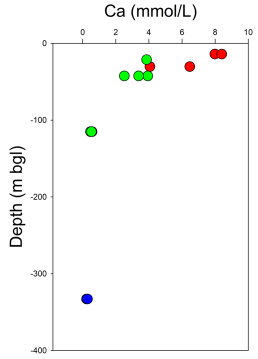

Fig. 3. Ca concentrations (0.29-8.92 mmol/L) in the groundwater samples reduce with depth

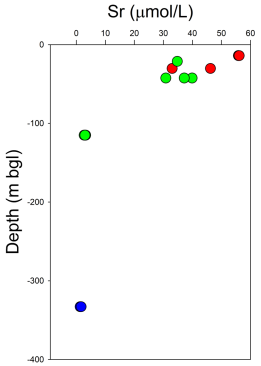

Fig. 4 Sr concentrations (1.6-62.8 µmol/L) in the groundwater samples reduce with depth

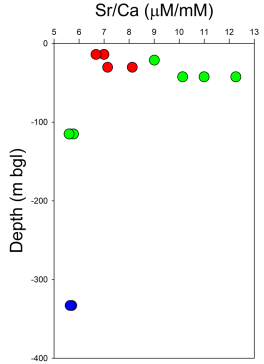

Fig.5. Variations in Sr/Ca in the groundwater samples with depth

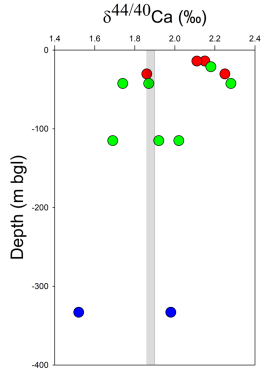

Fig. 6. $\delta^{44/40}Ca$ values of groundwater samples show significant variation (1.52-2.28‰); some samples collected from shallower depths display values higher than modern seawater (~1.88‰, vertical gray bar)

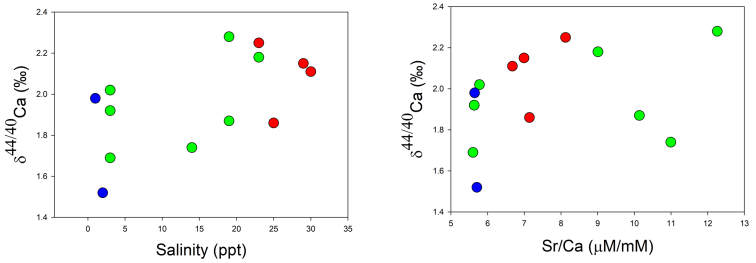

Fig. 7. Relationships between $\delta^{44/40}Ca$ values and salinity and Sr/Ca in the groundwater samples of the present study

4. Summary and Conclusions

- Lower $\delta^{44/40}Ca$ values in deeper groundwater, together with their low salinity, [Sr], and [Ca] are consistent with limited seawater incursion at depth.
- Shallower groundwater samples display higher $\delta^{44/40}Ca$ values which is consistent with greater influence of seawater.
- Some of the shallow samples show $\delta^{44/40}Ca$ values which are higher than seawater; some of these samples also display high Sr/Ca which is consistent with carbonate precipitation.
- High $\delta^{44/40}Ca$ values in groundwater samples from the Sundarbans delta could explain the high $\delta^{44/40}Ca$ values of coastal waters from the Bay of Bengal (Chakrabarti et al., Goldschmidt 2018)

References: K. Das et al., 2021, J. of Env Management,284; S. Mondal and R. Chakrabarti, 2018, JAAS, 33,141; R. Chakrabarti et al. Goldschmidt 2018,359.
Funding: Ministry of Earth Sciences, India (MoES/PAMC/H&C/103/2017-PC-II).