MAJOR ION CHEMISTRY AN INDICATOR OF CHEMICAL WEATHERING ALONG THE COURSE OF THE RIVER KABINI, SOUTH INDIA.

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Abstract: Rock composition and weathering rates are the key factors to govern river water composition. Kabini is an important tributary of river Cauvery, of the total drainage area of 6693 sq.kms. Its source lies in the western Ghats in Wynad of Kerala at an elevation of 2134mts. The river enters Karnataka near Bavali from south western side of the state. It flows for a total distance of 220kms and joins the river Cauvery at Tirumakudal –Narasipura. The course of the river follows the high grade lithology in both the states. An attempt has been made in the present study to understand the trend of chemical weathering along the course of the river through its major ion composition of surface water chemistry. In this regard eight surface-water samples were collected along the course of the river Kabini at an interval of 30kms and analyzed for major anion and cations. The chemical composition of the River water reflects the influence of silicate weathering.

IndexTerms: **Chemical weathering, Surface water chemistry, Kabini, Litho-units**

I. INTRODUCTION

Rock composition and weathering rates are the key factors to govern river water composition (Drever.,1994). surface water composition is controlled by number of factors like geology of the area, climatic variability, and anthropogenic activities. water chemistry throws a light on relationships between the weathering and climate (Brennan and Lowenstein., 2002). In global level number of attempts have been made to understand the affiliation between chemical weathering of bedrock and surfacewater chemistry (R Reynolds and Johnson., 1972;MillerandDrever.,1977;Dethier.,1986;Drever and Hurcomb., 1986; Rochette et al., 1988; Blum et al.,1994; Edmond et al., 1995). Many Indian rivers are also studied to understand the hydro geological characteristics of river basins, impact of bed rock composition, tectonics, climatic factors and anthropogenic activities on surface water chemistry and also contribution of elemental fluxes from rivers to ocean system(Subramanian.,1979;Subramanian.,1987;Sarin et al.,1989;Chakrapani and Subramanian.,1990;Ramanathanet al., 1994; Krishnaswami and Singh., 1998; Ahmad et.,al., 1998; Singh and Hasnain., 1999; Dalai et al.,2002; Sharma and Subramanian 2008; Rengarajan et al., 2009; Gupta et al., 2011).Chemical weathering of primary and secondary minerals will release the cations and anions (Garrels RM et.al.,1967). An attempt has been made in the present study to understand the trend of chemical weathering along the course of the river through its major ion surface water chemistry.

II.STUDY AREA

2.1. Study area and sample locations

Kabini is an important tributary of river Cauvery and is an inter-state river with 22% in Kerala and 78% in Karnataka out of the total drainage area of 6 693 sq.kms. It flows in between latitude 11°72'N and 12°21' N and longitude 75°84'E and 76°91'E. Its source lies in the Western Ghats in Wayanad district of Kerala state at an elevation of 2134 meters. The river enters Karnataka near Bavali from south western side of the state. It flows for a total distance of 220 kms and joins the river Cauvery at Tirumakudalu-Narasipur. The river drains a hilly and forested catchment in the upper reaches, where the average rainfall is 2322mm. The main tributary of Kapila river is the Nugu river which also originates in the western Ghats and joins the Kabini river about 3 km south of Hampapura in Karnataka state.

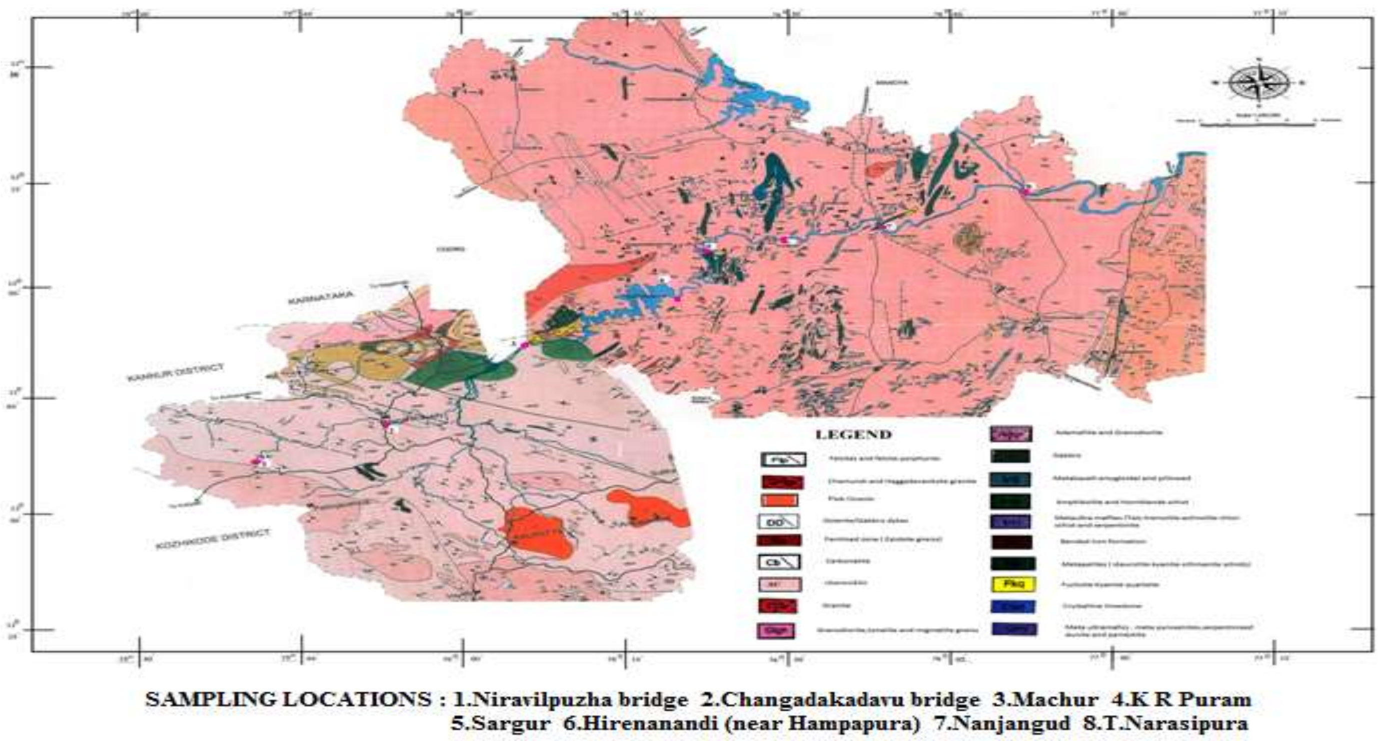

Fig.1:Geological map of the study area along with sample location.

2.2. Geology of the area

The river Kabini, since it flows across two states, it is necessary to have a brief glimpse of the geology of the area. Wayanad area in Kerala is divided into four geological domains viz. i) The peninsular Gneissic complex in the northern central part. ii) The migmatitic complex in the south central part. iii) The charnockites group in the south. iv) The Waynad group in the north which includes garnet-sillimanite-biotite gneiss with or without graphite, kyanite-fuchsite-muscovite-quartz-schist, hornblende-biotite schist and gneiss +/- garnet, amphibolite bands, quartz –sericite schist/ quartz – mica schist and meta ultramafites, representing upper amphibolites to lower granulite facies metamorphism. The Kabini river originates from north -west of Wayanad, where the rock type is predominantly hornblende-biotite gneiss, then the river flows over Gabbro in the northeast boundary area. In the latter stages it flows in Karnataka and it is made up of oldest rocks of the Dharwar craton representing the ancient supracrustals called the Sargur group of more than 3.0 Ga with wide spectrum of lithotypes. It is made up of meta igneous and metasedimentary rocks set a in a sea of peninsular gneiss, secondly, the river Kabini and its tributaries drain almost at right angles to the trend of Sargur supracrustals(Dhanya, A, V., et.al2017;Fazeli,et.al.,1989).

III. MATERIALS AND METHODS

The surface water samples were collected along the course of the river Kabini at an interval of 30kms for all three seasons i.e., Monsoon, Pre-monsoon and Post monsoon. Water sampling locations are shown in Fig. 1. The Freshwater samples were collected using cleanly washed (using HCl and distilled water) amber coloured glass bottles. The surface water samples were filtered by using 0.45-µm filter paper using a vacuum hand pump. Standard procedures (APHA 1998) were followed for the determination of Major ion concentrations in the ISI certified lab. Further, the ion balance error was computed to check the accuracy of the results which were within ± 5%.

IV. RESULT AND DISCUSSION

Major ion composition of the river is an integration of ions from different sources. Table 1 and Figure 2 representing the major ion composition along the course of the river.

Table.1 showing Chemical composition of surface water (Mg/L)

LOCATION	Na	K	Ca	Mg	Cl	SiO2	SO4	HCO3	TDS
DKS-1	3.66	0.66	5.33	1.55	4.66	9.24	3.33	20.73	41.33
DKS-2	5	0.66	6.8	2.8	6	10.39	4	28.44	54.66
DKS-3	9	1.33	8.26	4.56	11.33	17.04	5.33	45.11	85

DKS-4	6	2	5.86	3.36	9.66	13.55	4.33	28.44	69.66
DKS-5	9.33	1	10.66	5.28	9.91	12.55	4.66	57.21	91
DKS-6	13.66	1.66	13.6	8.64	12.66	16.53	5.33	73.58	126.66
DKS-7	18	1.66	17.86	13.36	16.33	17.92	8	131.37	171
DKS-8	21.66	1.66	26.66	16.4	25.33	20.33	9	170.40	222

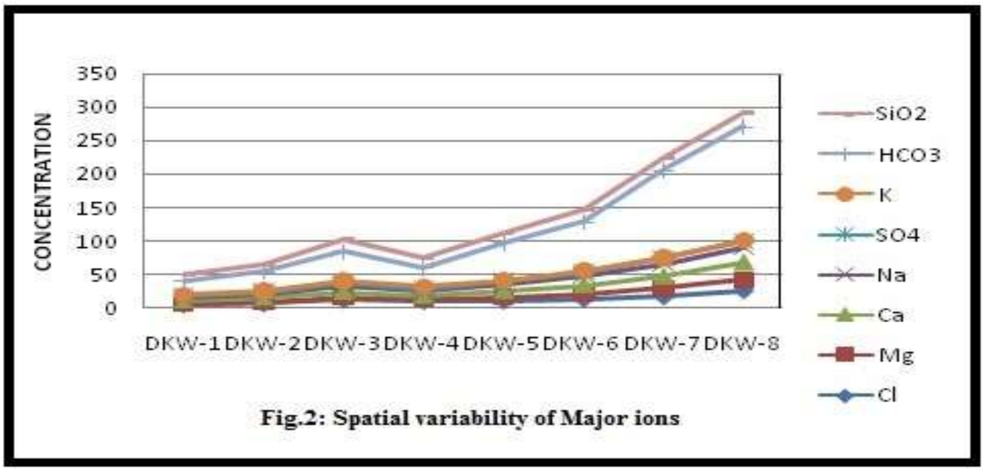

Fig.2: Spatial variability of Major ions

Total dissolved solids exhibiting a variability between 41.33 to 222 mg /l (Fig 3). Chemical weathering of litho-units along the river basin plays a key role in contributing major ions to surface water. Usually, River basins are multi-lithological, comprising silicates or carbonates and both. The determination of probable source rock by TDS values indicate carbonate weathering or saline water are greater than 500 mg/l, and that of silicate weathering is less than 500 mg/l (Hounslow,AW.,1995).

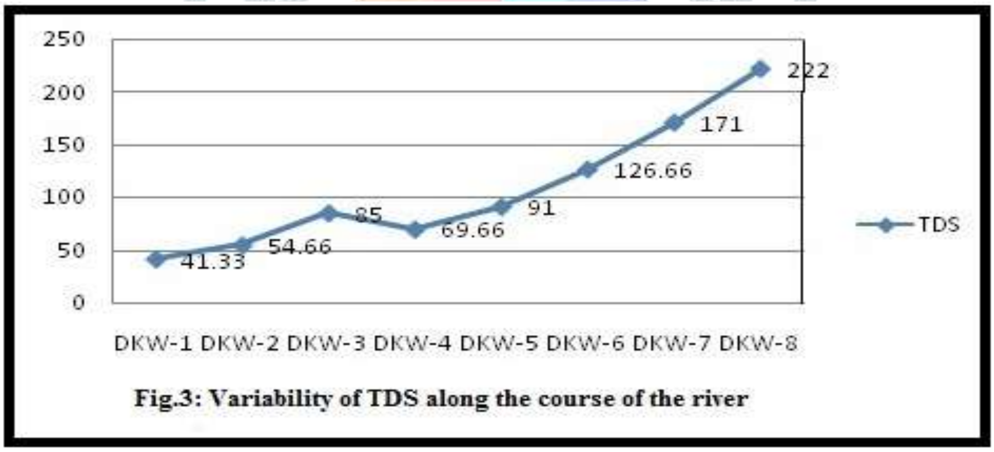

Fig.3: Variability of TDS along the course of the river

Silicate weathering of rocks along river basin would supply major ions to surface water. Some of surface water samples collected along the course showing high amount of Chlorine and Sulphate (Cl and SO4) indicates a major ion supply from anthropogenic activities like usage of excess fertilizers and also soils present in the river basin (Sarin, M et.al.,1989, Dalai,T,Ket.al., 2002).

Figure 4 represent the ternary plot of major cation and Figure 5 represent a ternary plot of anion abundance along the course of the river listed in Table 1.

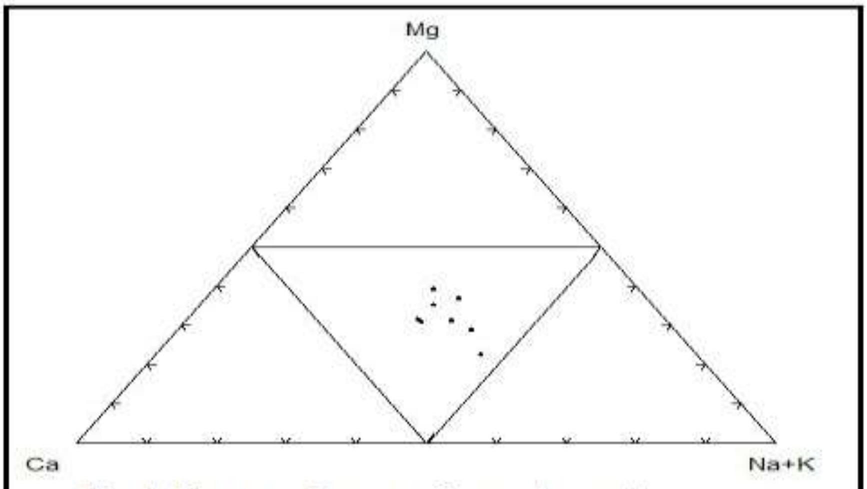

Fig.4:Ternary diagram for major cations

It is seen from Figure 4 that cations equally clustered indicating their direction due to weathering of felsic rocks like gneiss, mafic rocks like gabbro and also high grade metamorphic rocks present in the river basin and there is no single dominant source for these ions.

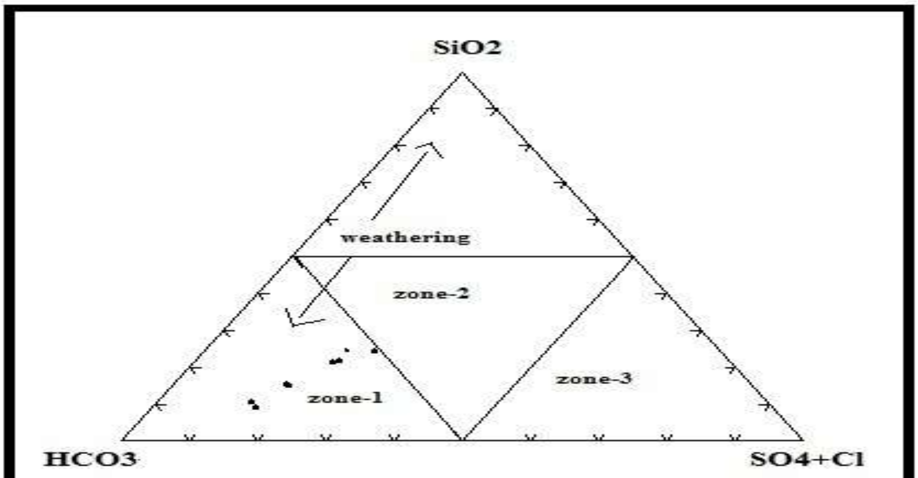

Fig.5: Ternary diagram showing Anion

In the anion ternary plot, ions are falling close to alkalinity apex, representing the dominance of HCO_3 release during the weathering process (Panigrahy,B,K et.al.,2005). When plagioclase feldspar weathers to kaolinite, the Ca/Na and HCO3/SiO2 mole ratio in water increases with increasing anorthite content (Garrels RM et.al.,1967) as shown in the following reactions.

$4An_50 + 6CO_2 + 9H_2O = 3Kaolinite + 2Na^+ + 2Ca_2 + 4HCO_3 + 2SiO_2$

$NaAlSi_3O_8 + 1/2H_2O = Na+ OH^- + 2H_4SiO_4 + 1/2Al_2Si_2O_5(OH)_4$

$NaAlSi_3O_8 + H_2CO_3 + 9/2H_2O = Na^+ + HCO_3^- + 2H_4SiO_4 + 1/2Al_2Si_2O_5(OH)_4$

$CaAlSiO_2O_8 + 3H_2O = Ca_2^+ + 2OH^- + Al_2Si_2O_5(OH)^4$

$CaAlSiO_2O_8 + 2H_2CO_3 + H_2O = Ca_2^+ + 2HCO_3^- + Al_2Si_2O_5 +(OH)^4$

The weathering of silicates minerals yield HCO_3^- as a product irrespective of parent minerals composition. Optional silica may be released in the same reaction according to the pH condition (Kumar,S,K et.al., 2009, El-Sayed,M,H et.al., 2012),Which contributes calcium and magnesium ions to surface water (Fig.6) (Katz,B,G,et.al.,1998). Along the course, all the samples falling below the line which divide to show the release of Ca + Mg from the silicate minerals.

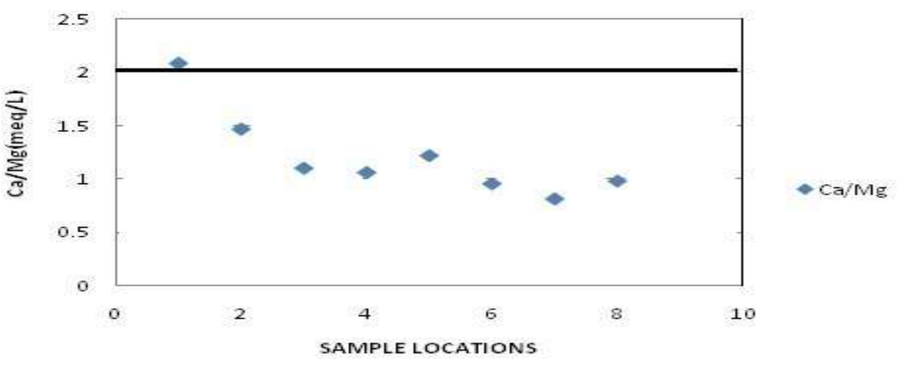

Fig.6: Ratio of cations showing silicate weathering

In Fig. 7 we can see the concentration of Calcium and sodium in surface water, more than 80% of the samples trending towards Na concentration due to the weathering of alkali minerals (Sharaky AM et.al.,2007).

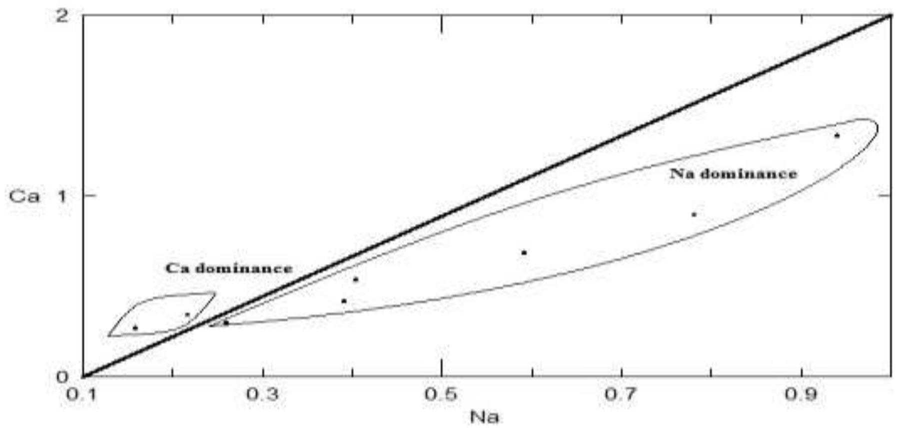

Fig.7: Na versus Ca scatter diagram shows that the concentration of Na in water

V. CONCLUSION

This study exhibits that the water of river Kabini is alkaline in nature, Ca2+, Na+ and HCO^-_3 are the major dissolved ions. The water chemistry is predominantly controlled by rock weathering with secondary contributions from soils and anthropogenic activities. The chemical composition of the river water reflects the influence of silicate weathering.

VI. ACKNOWLEDGMENT

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REFERENCES

[1] Ahmad T, Khanna P, Chakrapani G J and Balakrishnan S 1998 Geochemical characteristics of water and sediment of the Indus river, Trans-Himalaya, India: Constraints on weathering and erosion; J. Asian Earth Sci. 16 333–346.

[2] APHA 1998 Standard methods for the examination of waterand waste water, 20th edn; AmericanPublic HealthAssociation, Washington, DC.

[3] Biksham G and Subramanian V 1988 Nature of solute transport in the Godavari basin, India; J. Hydrol. 103 375–392.

[4] Blum,J . D., Y. Erel, and K. Brown,1994 87sr/86sr ratios of Sierra Nevada stream waters: Implications for relative mineral weathering rates, Geochim. Cosmochim. Acta, 58, 5019-5025.

[5] Brennan, S.T., Lowenstein, T.K., 2002. The major-ion composition of Silurian seawater. Geochim. Cosmochim. Acta 66 (15),2683–2700.

[6] Chakrapani G J and Subramanian V 1990 Preliminary stud-ies on the geochemistry of the Mahanadi river basin, India; Chem. Geol. 81 241–243.

[7] Dalai T K, Krishnaswami S and Sarin M M 2002 Major ion chemistry in the headwaters of the Yamuna river system: Chemical weathering, its temperature depen-dence and CO2 consumption in the Himalaya; Geochim. Cosmochim. Acta 66 3397–3416**.**

[8] Dethier, D. P.,1986 Weathering rates and the chemical flux from catchments in the Pacific Northwest, USA, in Rates of Chemical Weathering of Rocks and Minerals, edited by S. M. Coleman and D. P. Dethiers, pp. 503-530

[9] Dhanya.A.V.,K.N.PrakashNarasimha.,Vybhav.K.,2017,Geochemistry of Kabini river sediments:An insight into its provenance, Excel India publishers,pp.32-35.

[10] Drever,J.I.,andD.R.Hurcomb,1986,Neutralization of atmospheric acidity by chemical weathering in an alpine drainage basin in the North Cascades Mountains, Geology1, 4, 221-224.

[11] Drever, J.I., 1994. The effect of land plants on weathering rates of silicate minerals. Geochim. Cosmochim. Acta 58 (10), 2325– 2332.

[12] Edmond, J. M., M. R. Palmer, C. I. Measures, B. Grant, and R. F.Stallard,1995 The fluvial geochemistry and denudation rate of the Guyana Shield in Venezuela, Colombia, and Brazil, Geochim. Cosmochim. Acta, 59, 3301-3325.

[13] El-Sayed MH, Moustafa M, Shawk HA 2012 Impact of hydrochemical processes on groundwater quality, Wadi Feiran, SouthSinai. Egypt. Aust J Basic Appl Sci 6(3):638–654.

[14] Fazeli,M,S,Sathyanaryan,S,andSatish,P,N,1989,Environmental impact and heavy metal pollution-result of a multimatrix analysis of ecocomponents near Nanjangud, Mysoredistrict, Karnataka ,Sem. Natural resources utilization and environmental appraisal, Ravishankar university,India.

[15] Garrels RM, Mackenzie FT 1967 Origin of the chemical composition of some springs and lakes. In: Gould RF (ed) Equilibrium concepts in natural water systems. Advances in chemistry series, vol 67., American Chemical SocietyWashington, DC,pp 222–242

[16] Gupta H, Chakrapani G J, Selvaraj K and Kao S J 2011 The fluvial geochemistry, contributions of silicate, carbonate and saline–alkaline components to chemical weathering flux and controlling parameters: Narmada river (Deccan Traps), India; Geochim. Cosmochim. Acta 75 800–824.

[17] Hounslow AW 1995 Water quality data analysis and interpretation.Lewis, New York, pp 45–128

[18] Katz BG, Gopalan TB, Bullen TD, Davis JH 1998 Use ofchemical and isotopic tracers to characterise the interactionbetween groundwater and surface water in mantled karst.Groundw J 35:1014–1028

[19] Krishnaswami S and Singh S K 1998 Silicate and carbon-ate weathering in the drainage basin of Ganga–Ghagra– Indus head waters: Contributions to major ion Sr isotope geochemistry; Proc. Indian Acad. Sci. 107 283–291

[20] Kumar SK, Rammohan V, Sahayam JD, Jeevanandam M 2009 Assessment of groundwater quality and hydrogeochemistry of Manimuktha River basin, Tamil Nadu, India. Environ Monit Assess 159:341–351

[21] Miller, W. R., and J. I. Drever, 1977 Chemical weathering and related controls on surface water chemistry in the Absaroka Mountains, Wyoming,Geochim Cosmochim Acta, 41, 1693-1702.

[22] Panigrahy BK, Raymahashay BC (2005) River water quality in weathered limestone: a case study in upper Mahanadi basin, India. J Earth Syst Sci 114(5):533–543

[23] Ramanathan,A,L,VaithiyanathanP, Subramanian V and Das B K 1994 Nature and transport of solute load in the Cauvery river basin, India; Water Res. 28 1585– 1593.

[24] Rengarajan R, Singh S K, Sarin M M and Krishnaswami S 2009 Strontium isotopes and major ion chemistry in the Chambal River system, India: Implications to silicate erosion rates of the Ganga; Chem. Geol. 260 87–101.

[25] Rengarajan R, Singh S K, Sarin M M and Krishnaswami S 2009 Strontium isotopes and major ion chemistry in the Chambal River system, India: Implications to silicate erosion rates of the Ganga; Chem. Geol. 260 87–101.

[26] Reynolds,R.C.,andN.M. Johnson,1972,Chemical weathering in the temperate glacial environment of the northern Cascade Mountains, Geochim.Cosmochim. Acta, 36, 537-554.

[27] Rochette, E., J. I. Drever, and F. Sanders, 1988 Chemical weathering in the West Glacier Lake drainage basin, Snowy Range, Wyoming: Implications for future acid deposition, Contrib. Geol., 26, 29-44.

[28] Sarin, M. M., Krishnaswami, S., Dilli, K., Somayajulu, B. L. K.and Moore, W. S.,1989 Major ion chemistry of the Ganga–Brahmaputra river system: Weathering processes and fluxes to the Bay of Bengal. Geochim. Cosmochim. Acta, 53, 997–1009.

[29] Sharaky AM, Atta SA, El Hassanein AS, Khallaf KMA,2007Hydrogeochemistry of groundwater in the Western Nile Delta Aquifers, Egypt. In: 2nd International conference on the geology of Tethys. Cairo University, Giza, pp 19–21

[30] Panigrahy BK, Raymahashay BC 2005 River water quality in weathered limestone: a case study in upper Mahanadi basin, India. J Earth Syst Sci 114(5):533–543

[31] Sharma S K and Subramanian V 2008 Hydrochemistry of the Narmada and Tapti River, India; Hydrol. Process. 22 3444–3455

[32] Singh A K and Hasnain S I 1999 Environmental geo-chemistry of Damodar river basin – east coast of India; Environ. Geol. 37124–136.

[33] Subramanian V 1979 Chemical and suspended sediment characteristics of rivers of India; J. Hydrol. 44 37–55.

[34] Subramanian V, Biksham G and Ramesh R 1987 Environ-mental geology of peninsular river basins of India; J. Geol.Soc. India 30393–401.