

Chemical characteristics of aerosols in MABL of Bay of Bengal and Arabian Sea during spring inter-monsoon: A comparative study

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The chemical composition of aerosols in the Marine Atmospheric Boundary Layer (MABL) of Bay of Bengal (BoB) and Arabian Sea (AS) has been studied during the spring and inter-monsoon (March–May 2006) based on the analysis of water soluble constituents (Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+} , Cl^- , NO_3^- and SO_4^{2-}), crustal elements (Al, Fe, and Ca) and carbonaceous species (EC, OC). The total suspended particulates (TSP) ranged from 5.2 to 46.6 $\mu\text{g m}^{-3}$ and 8.2 to 46.9 $\mu\text{g m}^{-3}$ during the sampling transects in the BoB and AS respectively. The water-soluble species, on average, accounted for 44% and 33% of TSP over BoB and AS respectively, with dominant contribution of SO_4^{2-} over both the oceanic regions. However, distinct differences with respect to elevated abundances of NH_4^+ in the MABL of BoB and that of Na^+ and Ca^{2+} in AS are clearly evident. The non-sea-salt component of SO_4^{2-} ranging from 82 to 98% over BoB and 35 to 98% over AS; together with $\text{nss-Ca}^{2+}/\text{nss-SO}_4^{2-}$ equivalent ratios 0.12 to 0.5 and 0.2 to 1.16, respectively, provide evidence for the predominance of anthropogenic constituents and chemical transformation processes occurring within MABL. The concentrations of OC and EC average around 1.9 and 0.4 $\mu\text{g m}^{-3}$ in BoB and exhibit a decreasing trend from north to south; however, abundance of these carbonaceous species are not significantly pronounced over AS. The abundance of Al, used as a proxy for mineral aerosols, varied from 0.2 to 1.9 $\mu\text{g m}^{-3}$ over BoB and AS, with a distinctly different spatial pattern – decreasing north to south in BoB in contrast to an increasing pattern in the Arabian Sea.

1. Introduction

In the present-day scenario of growing anthropogenic activities, it is undisputedly recognized that atmospheric aerosols are one of the important driving parameters to regulate the chemical composition of the earth's atmosphere. Their significant impact on atmosphere is of utmost interest as they participate in various physico-chemical processes, scatter and absorb incoming solar radiation, provide active sites for the uptake of several chemical species and trace gases and act as cloud condensation nuclei (CCN) in modifying the cloud properties (Twomey 1977; Charlson *et al* 1992; Ramanathan *et al* 2001a, 2001b). The continen-

tally derived aerosols from natural (mineral dust) and anthropogenic (SO_4^{2-} , NO_3^-) sources, when transported to the remote marine environment, can perturb the marine ecosystem in a changing climate scenario (Prospero *et al* 1981; Martin *et al* 1989; Duce *et al* 1991; Arimoto *et al* 2001; Jickells *et al* 2005). The atmospheric aerosols exhibit a significant spatial and temporal variation owing to its short lifetime, which induces a large uncertainty in radiative forcing calculations. The systematic data on chemical composition of aerosols from oceanic regions is of great relevance in the present context in order to place better constraints on the input parameters in chemical transport models.

Keywords. Aerosol chemistry; water-soluble ions; carbonaceous species; mineral dust.

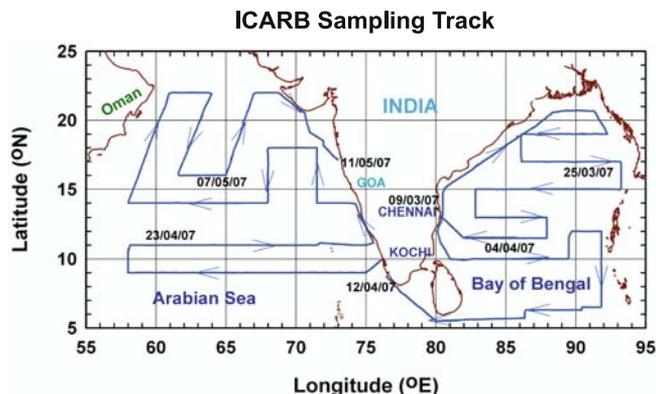


Figure 1. The cruise transects carried out in the Bay of Bengal and Arabian Sea for collection of bulk-aerosol samples during spring inter-monsoon (March–May 2006).

With this rationale, the ICARB (Integrated Campaign for Aerosols, gases and Radiation Budget) field experiment on an Indian scene was primarily designed to study several parameters of atmospheric aerosols and trace gases. The specific scientific objective of this campaign-based programme was to quantify the impact of long-range transport of aerosols and trace gases from different source regions of India, south China, and east Asia to the Bay of Bengal (BoB); and that from north-western India, west Asia and Africa to the Arabian Sea (AS). In this paper we report on the comparative chemical composition of aerosols from the two (BoB and AS) oceanic regions vis-à-vis continental outflow of mineral dust and anthropogenic species from the Indian subcontinent.

2. Methodology

2.1 Cruise track and meteorological conditions

Figure 1 shows the cruise track (cruise No. SK 223A and 223B) undertaken onboard ORV *Sagar Kanya*, during 18 March to 12 April, in the Bay of Bengal; and 18 April to 11 May 2006 in the Arabian Sea. Several transects were made between 5.6°N to 20.5°N and 80.4°E to 93.4°E in BoB and 9°N to 22°N and 77.3°E to 58°E covering almost an entire area of the Arabian Sea. The dots along the cruise track show the position of the ship at 05:30 UTC on each day. The prevailing winds were north-westerly during the SK 223A leg in BoB and remained same for the few early days of SK 223B; however changed to south-westerly towards the end of the cruise in Arabian Sea. The relative humidity varied from 50 to 100%, with a mean of about 80% during the entire campaign period. The prevailing winds, corrected for the ship's motion, were found to vary between 0.5 and

13.5 m/s, whereas surface-level pressure variations were recorded in the range of 1002 to 1016 mb. The winds were generally strong (~ 13 m/s) during the sampling transect in the central Arabian Sea and relatively moderate (~ 9 m/s) in the northern Arabian Sea.

2.2 Aerosol sampling and analysis

Bulk-aerosol samples were collected on PALLFLEXTM tisuquartz filters (20×25 cm²) by operating a high-volume sampler at a flow rate of about 1.5 m³ min⁻¹. The sampler was set-up on the upper deck, 16 m asl, in front of the ship's navigation room. A total of 23 and 19 samples were collected over BoB and AS respectively. Each sample was collected by running the sampler for an extended time-period, ranging from 18 to 24 h, whenever the ship was cruising at a speed of ~ 10 knots/h or above; thus avoiding contamination from the ship's exhaust. In the laboratory, Total Suspended Particulate (TSP) mass concentrations were assessed gravimetrically by weighing the full filters before and after sampling. Prior to their weighing, all filters were equilibrated at a relative humidity of $50 \pm 5\%$ and temperature of $22 \pm 1^\circ\text{C}$ for 5–6 h. Subsequently sample filters were subjected to chemical analysis of water-soluble constituents (Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+} , Cl^- , NO_3^- and SO_4^{2-}), crustal elements (Fe, Al and Ca) and carbonaceous species. For water-soluble components one-eighth of the filter was soaked in Milli-Q water (resistivity = 18.2 M Ω cm) for 10–12 h followed by ultrasonication; repeated leaching with water were combined and made to a known volume. The anions (Cl^- , NO_3^- and SO_4^{2-}) and cations (Na^+ , NH_4^+ , K^+ , Mg^{2+} , and Ca^{2+}) were analyzed on Ion Chromatograph with suppressed conductivity detector. Based on blank concentrations and the average volume of air filtered (~ 2000 m³), the detection limits for the water-soluble ionic species in aerosols were ascertained (18, 18, 20, 18, 25, 6, 10 and 30 ng m⁻³ for Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+} , Cl^- , NO_3^- and SO_4^{2-} respectively).

The crustal elements (Al, Fe and Ca) were analyzed by inductively coupled plasma-atomic emission spectroscopy (ICP-AES) on a separate one-eighth portion of the filter, digested using 0.5 ml HF and 3 ml HNO₃ in a microwave oven and total volume increased to 25 ml with Milli-Q water. Prior to acid digestion, filter was combusted in an oven at 400°C for three hours to oxidize the organic coating (if any) on the particulate matter. A multi-element commercial standard (1000 $\mu\text{g ml}^{-1}$ w.r.t. 23 elements), after suitable dilution, was used for preparation of analytical calibration curve. Based on the repeat analysis of a number of

samples and standards, reproducibility in the analytical data for crustal elements was within 10%. The concentrations of elemental carbon (EC) and organic carbon (OC) were determined by a thermal/optical analyzer (Birch and Cary 1996). Details of analytical protocol on EC-OC measurements used in our lab have been described in a recent article by Rengarajan *et al* (2007). The detection limit for OC and EC was 0.1 and $0.05 \mu\text{g m}^{-3}$ respectively; using 3σ value of total procedural blank concentration of the filter and volume of air sampled ($\sim 2000 \text{m}^3$).

3. Results and discussion

3.1 Air-mass back trajectory analysis

Air-mass back trajectories (AMBT) are one of the diagnostic parameters to infer the source region from where the aerosol mass has originated and the subsequent transport to the sampling location. The 7-day back trajectory analysis was made for the cruise duration, using the Hysplit-4 model and FNL-meteorological dataset at 50, 100, 500 m altitude, in order to track the origin of air parcels at various locations. During the initial phase of the cruise SK 223A, in BoB, the polluted air parcel from north-eastern India dominates the aerosols transport. During later part of the cruise covering southern transects in the BoB, winds originated within the oceanic region for a few days (28 March to 6 April); otherwise, the wind pattern remained more or less same (north-westerly) carrying the continental outflow to the marine environment.

In the Arabian Sea, the transition of wind regimes was discernible based on AMBT analysis. During initial phase of the cruise in the AS, AMBT originated from north-western part of Arabian Sea (off the coast of Oman). With the progressive cruise transects in the northern region of AS, the AMBTs show south-westerly winds originating within the MABL. The northward progression of ITCZ – a characteristic feature for the onset of SW-monsoon winds over the Arabian Sea was also observable. The ITCZ acts as a barrier to restrict the transport of continental (anthropogenic and natural) derived constituents to the south of ITCZ. During the winter-monsoon, a sharp gradient occurs across the ITCZ with concentration of nss-SO_4^{2-} , NH_4^+ , and nss-K^+ decreasing by an order of magnitude on the southern side of ITCZ (Norman *et al* 2003). This suggests that the entrainment of continental aerosols (transported during NE/NW-winds), north of ITCZ, will impact the abundances of chemical species in the central and northern Arabian Sea.

3.2 Total suspended particulate (TSP) matter

The abundance of TSP in the MABL of BoB and AS was found to vary from 5.2 to 46.2 and 8.2 to $46.9 \mu\text{g m}^{-3}$ respectively (table 1). Typical high values of TSP in BoB are observed at sampling locations along the south-eastern coast of India. Overall, a decreasing trend in TSP mass concentration was seen from north to south BoB; suggesting diminishing impact of atmospheric transport from continental sources. The AMBTs also confirm that air-parcels in the BoB have mainly originated from the Indian urban region. In contrast, high TSP abundances are observed in southern transect over AS, although the highest TSP ($46.9 \mu\text{g m}^{-3}$) was recorded on 8 May, in the northernmost transect of Arabian Sea. Transport from arid and semi-arid regions of Oman coast to southern Arabian Sea, and airmasses originating within the marine environment affecting the aerosol characteristic in northern Arabian Sea are also supported by AMBT analysis.

3.3 Water-soluble ions

Water-soluble inorganic species ranged from 30 to 72% (Av: 44%; sd: 12%) and 22 to 70% (Av: 33%; sd: 12%) of TSP in BoB and AS respectively. A comparison of charge balance between total cations (Σ^+) and total anions (Σ^-) in the water-soluble fraction of aerosols over the two regions is shown in figure 2. The Σ^+/Σ^- ratio varied between 0.89 and 1.30 (Av: 1.11; sd: 0.08) and 0.80 and 1.20 (Av: 1.06; sd: 0.09) over BoB and AS respectively. A relatively larger deviation of data points from 1:1 line is observable for water-soluble constituents in the MABL of BoB compared to the AS. This is attributed to the lack of bicarbonate measurement and hence resulting in cation excess. Rastogi *et al* (2005), had made direct measurements of bicarbonate ion in ambient aerosols over semi-arid regions and significant cation excess was reported during winter months (November–February). The dominant contribution from regional dust sources to the overall chemical composition of aerosols in the MABL of seas around India requires independent measurement of bicarbonate ion for the anion balance. Few earlier studies over the Indian region (Kulshrestha *et al* 1998; Momin *et al* 1999; Venkatraman *et al* 2002) have also demonstrated cation excess in the ion-balance.

The average aerosol composition of water-soluble species, in the MABL of BoB and AS, during the sampling period representing inter-monsoon season, is shown in figure 3; with dominant contribution of sulphate over both the regions. On average, contribution of SO_4^{2-} to TSP was 68 and

Table 1. Average concentration of chemical species in bulk-aerosols from MABL over Bay of Bengal (BoB) and Arabian Sea (AS), along with minimum and maximum values (all units in $\mu\text{g m}^{-3}$) and standard deviation of the data. Number of samples in BoB = 23; AS = 19.

Component	Bay of Bengal, $n = 23$				Arabian Sea [§] , $n = 19$			
	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
TSP	22.5	13.0	5.2	46.6	24.7	10.4	8.2	46.9
Water-soluble	8.9	3.7	3.8	15.7	10.7	5.9	2.7	23.7
nss-SO ₄ ²⁻	5.8	2.4	2.5	10.3	2.9	1.2	1.3	5.7
Al	0.92	0.54	0.19	1.89	0.85	0.47	0.21	1.89
Ca	0.73	0.36	0.20	1.42	0.90	0.60	0.13	2.48
Fe	0.59	0.31	0.15	1.22	0.44	0.27	0.09	1.01
Na ⁺	0.86	0.62	0.16	1.90	1.92	2.43	0.22	10.27
NH ₄ ⁺	0.90	0.63	0.01	2.29	BDL	BDL	BDL	BDL
K ⁺	0.24	0.11	0.08	0.43	0.12	0.08	0.04	0.42
Mg ²⁺	0.16	0.08	0.05	0.30	0.20	0.26	0.04	1.13
Ca ²⁺	0.68	0.35	0.17	1.42	0.85	0.56	0.12	2.24
Cl ⁻	0.013	0.010	BDL*	0.042	2.16	3.88	BDL	15.26
NO ₃ ⁻	0.075	0.089	BDL	0.35	0.40	0.40	BDL	1.34
OC	1.88	1.59	0.26	5.46	0.21	0.15	BDL	0.68
EC	0.39	0.16	0.12	0.66	0.08	0.03	BDL	0.20
POM	3.95	3.33	0.55	11.47	0.44	0.32	0.21	1.42
nss-SO ₄ ²⁻ (%)	28.7	8.9	19.0	50.2	12.7	4.3	3.0	20.7
Dust (%)	49.2	9.3	34.8	67.7	44.0	15.0	13.0	77.7
Sea-salts (%)	6.1	4.5	1.5	17.8	16.2	16.4	1.9	64.7
POM (%)	14.7	5.0	8.5	24.8	1.8	1.0	0.7	5.1

*BDL = Below Detection Limit.

[§]Kumar et al (2008).

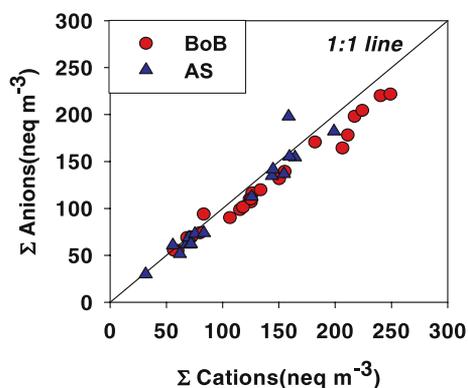


Figure 2. The charge balance between Σ cations and Σ anions over both oceanic regions for the water-soluble species in the aerosol samples. Anion deficiency is mostly observed in the Bay of Bengal which can be attributed to the presence of organic acids or HCO_3^- ions (not measured) in the water extracts.

47% over BoB and AS, respectively. The particulate SO_4^{2-} is formed by oxidation of SO_2 , with dominant contribution derived from fossil fuel combustion and relatively weaker source from biogenic gases such as dimethyl sulphide (in marine region). In addition, sea-salt also contributes to the SO_4^{2-} concentration. In the present study,

Na has been used as a reference for sea-salts. The $\text{Mg}^{2+}/\text{Na}^+$ ratios (in equivalent units) in the Arabian Sea are quite similar to their abundances in sea-water ($\text{Mg}^{2+}/\text{Na}^+ = 0.22$ in sea-water). But consistently higher $\text{Mg}^{2+}/\text{Na}^+$ ratio in the MABL of BoB could be attributed to the transport of alkaline fly ash from coal-fired power plants. The sea-salt corrected component of SO_4^{2-} is estimated as $\text{nss-SO}_4^{2-} = [\text{SO}_4^{2-}]_{\text{Total}} - [\text{Na}^+] * 0.2516$. The nss-SO_4^{2-} abundance varied from 2.5 to $10.2 \mu\text{g m}^{-3}$ (Av: $5.7 \mu\text{g m}^{-3}$; constituting 92% of total SO_4^{2-}) in the MABL of BoB and 1.3 to $5.7 \mu\text{g m}^{-3}$ (Av: $2.9 \mu\text{g m}^{-3}$; constituting 86% of total SO_4^{2-}) over AS respectively. The relatively higher abundance of nss-SO_4^{2-} over BoB suggests greater influence of anthropogenic sources to aerosol loading over BoB. A scatter plot between nss-Ca^{2+} and nss-SO_4^{2-} (in equivalent units) is shown in figure 4, showing significant correlation, $r^2 = 0.67$ and 0.62 with slopes = 0.73 and 2.23 for AS and BoB respectively. These results together with nss-Ca^{2+} contributing 95 and 89% to the total Ca^{2+} over BoB and AS, respectively, suggest their long-range transport from continental sources.

Another notable feature of the water-soluble species over the two oceanic regions relate to

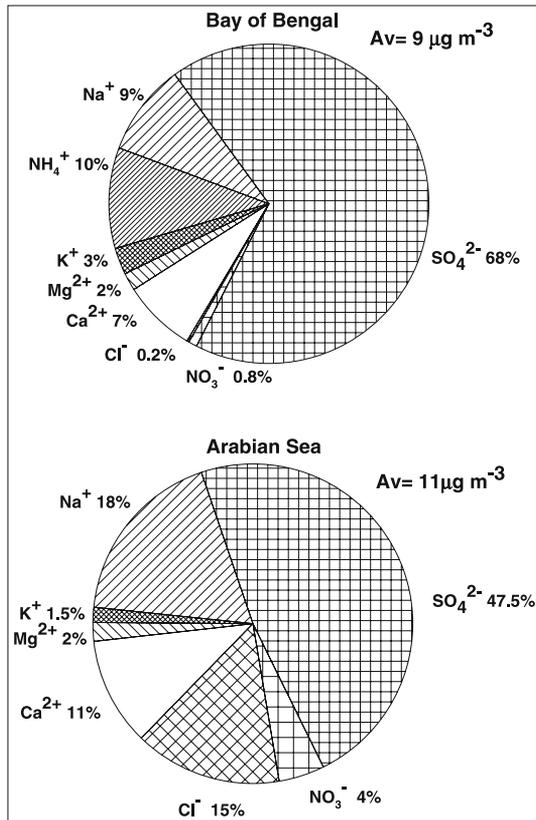


Figure 3. Average water-soluble composition of aerosols over Bay of Bengal and Arabian Sea, reflecting dominance of SO_4^{2-} .

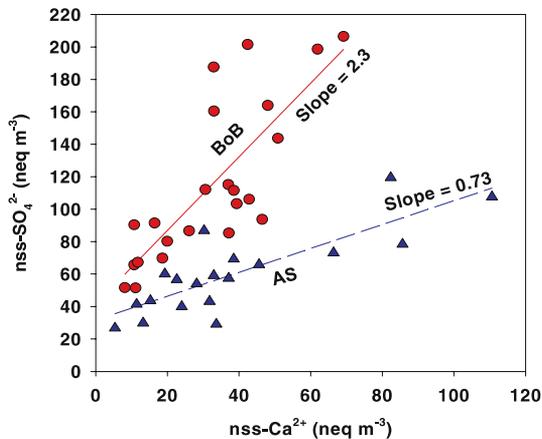


Figure 4. The linear regression analysis among nss-Ca^{2+} and nss-SO_4^{2-} abundances exhibits different slopes for the data from two oceanic regions. Relatively higher slope for BoB indicates the dominance of anthropogenic sources over this oceanic region.

Cl^- -deficit with respect to the expected abundance of Cl^- based on Na^+ and Cl^- ratio in sea-salts. Chloride-deficit is the process by which acidic species mainly nitrate, sulphate and some organic acids, react with NaCl in sea-salt particles and

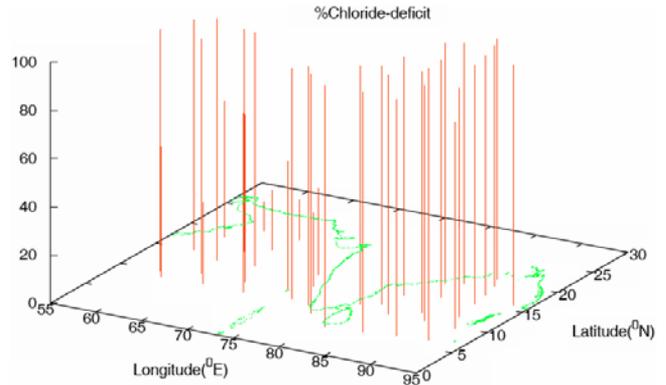


Figure 5. The spatial and temporal variability in the Cl^- -deficit (%) observed over Bay of Bengal (19 March to 12 April) and Arabian Sea (18 April to 8 May).

replace chloride in the form of HCl gas. The chloride deficit has been calculated as follows:

$$\text{Cl}^- \text{ deficit (\%)} = [(\text{Na}^+ \times 1.16) - \text{Cl}_{\text{m}}^-] \times 100 / (\text{Na}^+ \times 1.16), \quad (1)$$

where $(\text{Na}^+ \times 1.16)$ is expected Cl^- concentration from sea-salts, in absence of any loss of Cl^- and all Na^+ in ambient aerosols is of sea-salt origin, Cl_{m}^- is chloride measured in the sample. A large Cl^- -deficit was observed in the MABL over BoB (86 to almost 100%; Av: 98%) compared to AS (12 to 100%; Av: 62.7%). The spatial variability in the Cl^- -deficit in the two oceanic regions is shown in figure 5. The magnitude of Cl^- -deficit was found to decrease with increasing particle size (Kerminen *et al* 1998). The increased Cl^- -deficit over BoB than in the AS indicates the dominance of finer aerosols (anthropogenic input); an observation also supported by relatively high abundance of nss-SO_4^{2-} .

The concentration of NO_3^- is insignificant over both regions representing background concentration levels over these oceanic regions, while relatively higher abundance of K^+ over BoB indicates the biomass burning emissions from central/north-eastern part of India and their subsequent transport to northern BoB. However, it is noteworthy that the NH_4^+ contribution to the water-soluble species is significant over BoB, and is nearly absent over AS. Particulate NH_4^+ is formed by reaction of ammonia gas with acidic species and NaCl present in sea-salts. However, the formation of ammonium nitrate and ammonium chloride by these interactions are thermodynamically unstable and can cause a negative artifact for particulate NH_4^+ (Witz *et al* 1990). Over BoB, one of the main

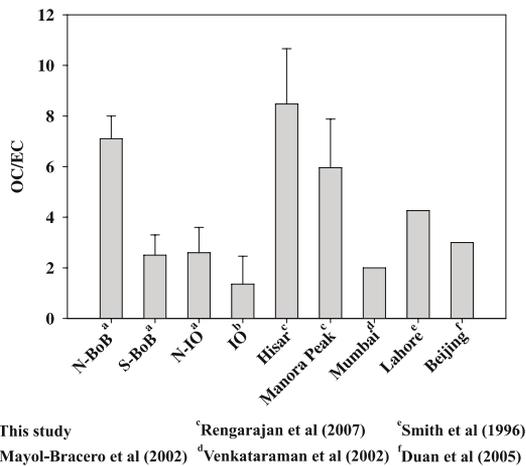


Figure 6. Comparison of OC/EC ratio from adjacent urban and remote locations.

neutralizing species of acidic SO_4^{2-} component is NH_4^+ , but over the AS, the major neutralizing agent is alkaline dust.

3.4 Carbonaceous aerosols

The abundance of carbonaceous species in the MABL of Bay of Bengal shows a large spatial variability; organic carbon (OC) varied as: $0.3 - 5.5 \mu\text{g m}^{-3}$ (Av: 1.9 ; sd: 1.6) and elemental carbon (EC): $0.12 - 0.7 \mu\text{g m}^{-3}$ (Av: 0.4 ; sd: 0.2) (table 1); with a conspicuous decreasing trend from north to south BoB. In contrast, the contribution of EC and OC to the TSP is insignificant along the entire cruise track in the Arabian Sea. The abundance of EC and OC varied from <0.05 to $0.2 \mu\text{g m}^{-3}$ (Av: $0.08 \mu\text{g m}^{-3}$) and <0.1 to $0.68 \mu\text{g m}^{-3}$ (Av: $0.21 \mu\text{g m}^{-3}$) respectively. Using OC concentration, mass of particulate organic matter (POM) has been estimated over both regions (Turpin and Lim 2001; Quinn *et al* 2002; Kumar *et al* 2008). It is evident from earlier discussions that the relative dominance of anthropogenic sources over BoB is also reflected in the abundance of carbonaceous species.

EC is considered to be primary aerosols in contrast to OC which get produced along with EC and can have biogenic as well as secondary sources from the precursor gases (Sun and Arya 2006). The relatively higher OC/EC ratio (7.1) in the north-BoB could be attributed to additional sources of OC other than primary emission source and the formation of secondary organic aerosols during long-range transport (figure 6). The observed ratio in northern BoB is higher than that estimated from the emission inventories for India and south-Asian countries (~ 3.3 ; Bond *et al* 2004). A recent study carried out on carbonaceous species from an urban site in north India by Rengarajan *et al* (2007),

has reported a very high value for OC/EC ratio (8.47 ± 2.19). Such high ratios have been ascribed to the regional scale biomass burning sources and dominant role of secondary organic carbon. The OC/EC ratios observed in north-BoB therefore, resemble the continental outflow from northern India but ratios (2.5 and 2.6) in south-BoB and north Indian Ocean (NIO) are typically enriched in EC, similar to those reported for urban cities (figure 6).

3.5 Mineral aerosols (Al, Fe and Ca)

The abundance of aluminum (Al) is typically used as an indicator of mineral aerosols of crustal origin (Tindale and Pease 1999; Rastogi and Sarin 2006). However, depending on the lithology of the dust source region, its percentage can vary to a large extent. Moreover, anthropogenic sources may also contribute to atmospheric Al at certain locations. Thus atmospheric Al abundance at certain sites cannot be simply converted into “mineral aerosols” because it may possibly represent dust as well as anthropogenic fraction containing enriched aluminium. In the following discussion, we have used Al concentration as an indicator of dust.

In addition, Fe and Ca have been also used as a diagnostic tracer for dust. During this study, the average concentrations of Al, Fe and Ca centered around 0.92 , 0.59 , 0.73 and 0.85 , 0.44 , $0.90 \mu\text{g m}^{-3}$ in the Bay of Bengal and Arabian Sea respectively (table 1). A decreasing trend in the abundance of Al is observable from north to south BoB. AMBT analysis indicates that in northern BoB, air parcels are moving from Indian mainland carrying Al and Fe enriched soil dust to the marine region resulting in higher Al concentration. The spatial distribution of Al in the AS shows a conspicuous decreasing trend from southern to northern transect. This decreasing pattern is associated with the changes in wind patterns from north-westerlies (over the southern part) to the south-westerlies prevailing in the northern Arabian Sea. The north-westerly winds transport dust from the coast of Oman; whereas high winds ($9-10$ m/s) prevalent in the northern transect are associated with relatively high abundance of sea-salts. The sources of dust over the Arabian Sea primarily include transport from Oman, Yemen and Rub-Al-Khali sand-sea and, to some extent the sabkha complexes along the south-eastern coast-line of Arabian Peninsula (Pease *et al* 1998).

One of the important objectives of this study is to characterize the mineral aerosols over the two regions by using crustal element ratios (Fe/Al and Ca/Al). It is assumed that sampling during the spring-intermonsoon season is representative of the dust transport to the MABL from

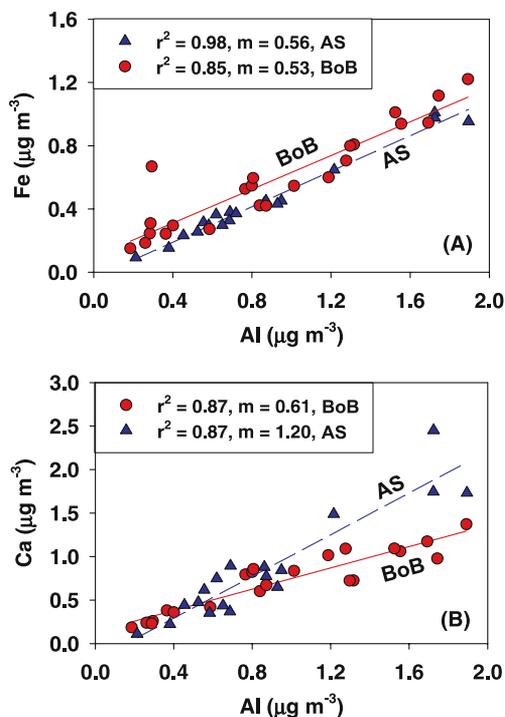


Figure 7. Scatter plot of Al with crustal components (Fe and Ca) exhibit characteristically different slopes for Ca *vs.* Al but remarkably similar for Fe *vs.* Al.

the regional source regions. The linear regression analysis performed among these elements, considering Al as index of dust, yields significant regression coefficients: Fe ($r^2 = 0.85$ and 0.98), and Ca ($r^2 = 0.87$ and 0.87) for BoB and AS respectively, suggesting their cogenetic source and/or no fractionation during transport to the MABL (figure 7). The average Fe/Al ratio observed over BoB and AS is 0.72 ± 0.37 and 0.51 ± 0.05 , relatively higher than Fe/Al ratio in upper continental crust (0.44 ; Taylor and McLennan 1985). On the other hand Ca/Al ratio, 0.81 ± 0.16 and 0.89 ± 0.27 , a factor of 2–3 higher than that expected from UCC (0.38 ; Taylor and McLennan 1985) indicates that dust is rich in calcium carbonate with a high capacity to neutralize acidic species. The neutralization of acidic species (sulphate) by dust is revealed from linear regression observed among nss-SO_4^{2-} and nss-Ca^{2+} (figure 4); with molar ratio of $\text{nss-Ca}^{2+}/\text{nss-SO}_4^{2-}$ ranging from 0.12 to 0.50 ($A_v = 0.28$) and 0.20 to 1.16 ($A_v = 0.61$); attesting to the fact that nss-SO_4^{2-} dominates in BoB whereas Ca^{2+} dominates in the AS.

4. Conclusions

The chemical characteristics of bulk-aerosols from the MABL of Bay of Bengal and Arabian Sea,

studied during the spring and inter-monsoon seasons, reveal comparable abundance of TSP over the two oceanic regions. However, the relative dominance of non-sea-salt sulphate and NH_4^+ in the water-soluble ion composition of bulk-aerosols over BoB, in contrast to Arabian Sea, arises from advective transport of continental pollutants to the Bay region. This is further reflected in the higher abundance of OC and EC over BoB. The near quantitative Cl^- -depletion from sea-salts by chemical interaction with anthropogenic sulphate provides added evidence to the processing of acidic species within the MABL. This has implication to the role of sea-salts as a dominant sink for sulphur dioxide. The relatively higher mass fraction of mineral dust over southern Arabian Sea than over north-Arabian Sea is a notable feature of this study. This feature indicates that the composition of air sampled in the northern section is quite different from the air mass transported to the south Arabian Sea.

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