Research Article

Monitoring of marine environment and exploration opportunities in Indian and Southern ocean during Antarctica expedition

Abstract

Environmental monitoring and assessment of marine environment of Indian Ocean and southern ocean is a big opportunity during the Antarctica scientific expedition. Distribution of major and minor element concentrations in surface seawater samples can be evaluated. Seawater samples must be collected from several pre-decided sampling location in Indian and Southern Ocean from latitude S 67º16'10.9" and longitude E 28º39'64.5" to latitude S 69º17'42.9" and longitude E 76º13'23.3" and to be analyzed for various heavy metals like copper (Cu), lead (Pb), cadmium (Cd), zinc (Zn), nickel (Ni), chromium (Cr). The concentrations of heavy metals Cu, Pb, Cd, Zn, Ni, Cr and other major elements like sodium, potassium, calcium, magnesium, boron were measured in selected seawater samples using Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES).

Keywords: metals, seawater, Antarctica, Southern ocean

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Pawan Kumar Bharti
Antarctica Laboratory, R & D Division, Shriram Institute for Industrial Research, India

Correspondence: Pawan Kumar Bharti, Antarctica Laboratory, R & D Division, Shriram Institute for Industrial Research19, University Road, Delhi-110 007, India,
Email gurupavvanbharti@rediffmail.com

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Introduction

Processes which control the distributions and variability of trace elements especially metals in coastal zones remain poorly understood due to the lack of strong research set ups and networks. Existing knowledge of most continental shelf waters is sufficient only to establish that nearshore trace metal concentrations are usually elevated relative to open ocean waters at similar depths, reflecting both natural and anthropogenic inputs at the ocean margins.[1,2] The limited understanding of the chemical variability in coastal waters is due in part to data limitations by laborious and slow analytical procedures and techniques for metals in seawater. These understandings are relatively less common in some less explored and pristine environments like southern ocean.

Our understanding of the biogeochemical cycles of trace elements and their influence on the oceanic ecosystem of the Southern Ocean is still limited, with perhaps the exception of iron.[3] Certain trace metals have profiles that are nutrient-like, like cadmium (Cd) and copper (Cu), which is indicative of their involvement in biological cycles.[4] In contrast, other metals have a scavenged-type behavior like lead[5] or behave in a conservative manner like uranium.[6] Elements such as manganese (Mn) can be considered hybrid-type metals at high latitudes, as their distribution is controlled by both biological uptake and scavenging processes.[6] Furthermore, the oceanic behavior of other trace metals like silver (Ag) is still not well understood, with little data on Ag distributions in the global ocean, notably in the Southern Hemisphere.[7] Despite major advances on the ecological involvement of trace metals and their geochemical dynamics in the ocean, basic knowledge is still lacking on their biogeochemical cycles. For instance, there are only a few comprehensive datasets of Mn,[8] and of Cu, Cd and Pb[9] for the Southern Ocean. The external sources of trace metals to the southeastern Atlantic and the Southern Ocean are not well constrained. Recent work suggests the importance of advection of water masses enriched in trace metals following contact with continental margins,[10,11] in addition to atmospheric depositions to surface waters and inputs from hydrothermal vents to bottom waters.[12] The coupling between trace and major nutrients cycles, such as the correlations between Cd and phosphate (PO_4) in the Southern Ocean,[13] indicates the removal of trace nutrients in surface waters due to phytoplankton uptake and their later sinking and remineralisation in deep waters. However, our knowledge of this coupling is still limited to a small number of trace elements.[14]

Some literature concerning heavy metals in the snow, ice, seawater, atmosphere, soil, rock and animals in the Antarctic region has been published.[15–18] However, analytical data on the Antarctic marine ecosystem including the seawater and biological materials for understanding the detailed distribution and bioaccumulation processes of heavy metals are rather scarce.[19,20]

The Antarctic marine ecosystem, especially beyond south of the Antarctic Convergence, is stable and old and has a higher percentage of endemic species: thus it is simple in comparison with other ecosystems. Since the atmospheric mixing between north and south of the Antarctic Convergence is very slow, the Antarctic area is a comparatively closed environment.[21] Aquatic systems such as the seawater, inland water, etc. are important stages in the biogeochemical cycle. Although dissolved levels are usually in the trace range of 10^{-6}-10^{-9}Ml^{-1} they remain significant, because they enter into the food chain and interactions with suspended particulate and sediments largely occur via the dissolve state.[6]

In environmental research, toxic metals particularly Cd, Pb, Ni, Cr, etc. are becoming increasingly signification owing to their biological non-degradability and chronic toxicity results from their accumulation in vital organs of humans. The various heavy metals in seawater become toxic if present in excessive quantities and pose a potential threat to the ecosystem. Therefore, there has been constant effort to measure the impact of these metals on fauna.[22] Trace metals in seawater, although present in very low concentrations, have a profound influence on marine biogeochemistry and function as critical indicators of fundamental processes. However, given the lower concentrations of many of the analytes of interest and a generally poor understanding of speciation within the matrix, chemical analysis of seawater is uniquely difficult. Potential interference from total dissolved solids often prevents accurate determination of the ambient levels of trace metals, making most traditional analytical method ineffective.

Few researchers are engaged in monitoring and assessment work especially on metal detection in water bodies and have done some work in this regards.[17,18,24–28] The objective of the research work is to identify, evaluate and predict the impact of increasing anthropogenic activities on environmental components of Antarctica. The generated data may reveal some interrelations of geo-genic and anthopogenic activities in natural aquatic ecosystem. Selection of such a huge sampling stretch and its planned sampling and analysis work will disclose some relationship between some elements and their availability, movement and distribution in the earth ecosystem. On the other hand, the outcome this work will compensate and try to envelop the gaps in research work in this particular area of analytical research.

Material and methods

Study area

Environmental monitoring and impact assessment studies were carried out in Antarctica during the austral summer seasons of various Indian Scientific Expeditions to Antarctica.[29] Long voyage from Goa (India) to Cape Town (South Africa) and further to east Antarctica (Maitri station to Bharati station) provides an opportunity to find out and evaluate the surface seawater quality of entire Southern Ocean stretch from Indian Bay to Larsemann Hills aboard Russian M/V Emerald Sea.

The surface seawater samples can be collected from Indian Bay (near Maitri station, Queen Maud Land) to Bharti station (Larsemann Hills, Ingrid Christenson Coast) in the Southern Ocean during Indian Scientific Expedition to Antarctica (ISEA). A few sampling points can be selected at various locations, from Indian bay to Larsemann hills in east Antarctica and the collected samples must analysed for the major elements and trace metal concentrations in surface sea water. The location map of study area and sampling stretch in the Southern Ocean is given in the Figure 1.

Sampling

The sampling of surface seawater carried out during the voyage at an interval of approximately 6 or 8 degree difference in the longitude. Sampling vessel, rope, sampler's hands must be disinfected using IPA to avoid the contamination. The samples must be collected in the Gamma irradiated, clean and sterilized PET bottles. As per the standard specifications, an appropriate quantity of Sodium thiosulphate is also placed in the PET bottles to avoid the chlorine contamination. Collected seawater samples must immediately filtered through a 0.45pm membrane filter using a vaccum filtration apparatus and stored in vertical position maintaining the temperature 1–4°C with ice pack enveloped conditions immediately after preservation by 1ml 70% HNO_3. The samples must be transported to the laboratory using ice boxes after completion of expedition and analyzed for the major elements and trace metals. Aseptic conditions must be maintained during the collection of samples. The samples must be kept in an ice pack to prevent any contamination of any foreign material or microbial flora of the samples during the transportation.

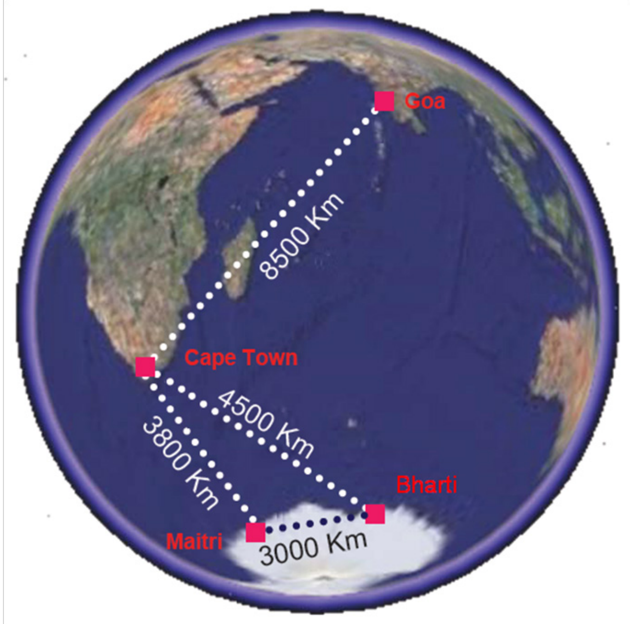

Figure 1 Location map and sampling stretch in Indian and Southern Ocean.

Analytical methods

Using a deliberate combination of oxidation, reduction, precipitation, extraction, chelation, filtration and concentration processes, trace metals can be precisely measured in seawater.[30] Depending upon the analyte of interest, seawater is then analysed using hydride generation atomic fluorescence spectroscopy (HG-AFS), Induced coupled plasma mass spectrometry (ICP-MS), or cold vapour atomic fluorescence spectrometry (CV-AFS) up to very low detection limits.[31] Standards methods as described in APHA, 2005[32] must be followed for the dilution and analysis for various elements.

The analytical method used in this study must obtained from the modification of the one described by Jerez et al.,[33] The elements are determined by optical emission spectrometry with inductively coupled plasma (ICP-OES). All of the reagents used will be of Analytical grade (Merck) and the water was double-distilled and deionized (Milli-Q system, Millipore, USA). The analytical precision must be verified by using of blanks every five samples, initial calibration standards and CWW-TM-D certified reference material. The detection limit values, the reference material values and the percentage of reliability for each element must also calculated accordingly. The detection limit of each element should calculated by using the formula; DL=3sB/a (DL: detection limit; sB: standard deviation of the number of counts corresponding to zero on the calibration line; a: the constant of the calibration line).

Results and Discussion

In the analyses of seawater during the beginning of the 19th century in laboratories, problems arising from changes in chemical composition through evaporation, biological activity, or chemical interactions with the containing vessel, forced the marine chemist to transfer his laboratory from land to ships. Today, there is a strong and necessary trend toward using instrumental techniques, as opposed to the classical methods, especially when assaying very small amounts

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of materials.[34] Temperature and pH of sea water samples must be recorded on spot and are presented in tabular form.

Major elements

Sodium, potassium, calcium, magnesium, boron and iron metals must be analysed and probably found to be the dominant constituents among the sea water contents. Beside these, aluminum (in µg/cc) and zinc should also also present in significant quantities in all seawater samples.

Metals

Presence of cadmium in marine environment, shows the doubtful distribution concept over cadmium introduction into sea ecosystems. Similar trend may be observed for cobalt metal in seawater samples collected from coastal regions of Southern Ocean. Chromium concentration may be below detection level in almost all seawater samples. Selenium is also below detection level in all samples. Lead may be present in only few samples. Nickel is also one of the rarest metals in seawater as it was detected in only a few samples. Beside these, copper, manganese and molybdenum must also be present in all seawater samples in trace quantities. Few metals are biologically essential to living organisms in trace quantities in sea ecosystem. These trace metals may re-circulate from sediment and became available for biota.[35]

Dispersion of constituents and spot values from India to South Africa and further Antarctica

A significant variation may be found in the total concentrations of metals at different sampling locations. The results will indicate that the concentrations of metals in seawater may be uniformly distributed in selected stretch without any tremendous fluctuations. Aluminum, zinc, molybdenum and copper may also found in sufficient concentrations in all seawater samples. Arsenic, barium and phosphorous may not be detected. Strontium may also be found as one of the dominant alkaline earth metals in sea water samples.

Conclusion

Highest value of sodium, potassium, magnesium and calcium metals must be analysed and discussed in Indian and Southern Ocean. The trends of distribution must indicate the minimum turbulence and storage tendency of constituents in seawater. Temperature may also play an important role to regulate this functioning in sea ecosystem. All the metals and trace elements may be observed almost uniformly available in the surface seawater near east Antarctica, while fluctuating in Indian ocean. Some inputs may arise from the outer environment due to the anthropogenic reasons.[36–38] Spot values of different metals in sea stretch from Maitri Station to Bharti Station, east Antarctica will show very interesting distribution trends in Indian Ocean and Southern Ocean near Antarctica. However, water temperature and stagnancy may influence over heavy metals dispersions and many characteristics of seawater including biogeochemical cycle of microelements in Southern Ocean.[16,14]

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Conflicts of interests

Authors declare that there is no conflicts of interest

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