

MINOR CONSTITUENTS OF INDIAN SEA-WATER

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THE quantities of nine minor constituents in Indian sea-water (Bhavnagar coast) were reported in an earlier note.¹ The present communication deals with the estimation of fourteen minor elements, including the nine reported earlier, and the analytical procedures followed.

EXPERIMENTAL

Samples of sea-water were collected near the Bhavnagar port during high tides in the months of March to April. The density of sea-water was between 3.0°–3.3° Be'. The brine was filtered and stored in chemically resistant glass vessels. The data obtained on analysis of this sea-water and the corresponding data for ocean waters elsewhere are included in Table I.

in presence of mannitol. The method as modified by Foote³ for sea-water was adopted.

4. *Fluorine*.—Fluorine was determined colorimetrically using zirconium alizarin sulphonate as indicator.⁴ The colour developed by the indicator was measured colorimetrically in Nessler tubes and compared with those of the standard solutions in the range from 0.10 to 1.20 milligram fluorine per litre.

5. *Rubidium*.—Since Rubidium content in sea-water is very small, fifteen litres were concentrated to a volume of 1.5 litre. The salts separated during evaporation were washed with alcohol and from the collected filtrate and washings rubidium and potassium were

TABLE I

Minor constituents of Indian sea-water

| No. | Constituent of sea-water | Indian sea-water (Bhavnagar coast) | Known values for other oceans | Reference |
|-----|--------------------------|------------------------------------|-------------------------------|--|
| | | | (Microgram per litre) | |
| 1 | Bromine | 43,600 | 64,600 | Barnes (1951) ¹⁴ |
| 2 | Strontium | 11,800 | 9,000–11,000 | Smales (1951) ¹⁵ |
| | | | 8,150 | Odum (1951) ¹⁴ |
| 3 | Boron | 2,200 | 1,530–5,100 | Igelsrud <i>et al.</i> (1938) ¹⁴ |
| 4 | Fluorine | 800 | 1,400 | Thompson and Taylor (1933) ¹⁶ |
| 5 | Rubidium | 640 | 200 | Goldschmidt (1937) ¹⁶ |
| 6 | Silicon | 515 | 10–1,000 | Armstrong (1951) ¹⁶ |
| | | | (depending on depth) | |
| 7 | Lithium | 160 | 100 | Thomas and Thompson (1933) ¹⁶ |
| 8 | Iron | 160 | 15–50 | Thompson and Bremner (1935) ¹⁶ |
| 9 | Iodine | 44 | 50 | Reith, Schultz (1930) ¹⁶ |
| 10 | Phosphorus | 41 | 0–90 | Barnes (1951) ¹⁴ |
| 11 | Copper | 30 | 1–25 | Chow and Thompson (1952) ¹² |
| 12 | Aluminium | 26.8 | 27–270 | Armstrong (1951) ¹⁶ |
| | | | 160–1,800 | Haendler and Thompson (1939) ¹⁷ |
| 13 | Manganese | 2.5 | 1–10 | Thompson and Wilson (1935) ¹⁶ |
| 14 | Arsenic | 0.46 | 1.6–5 | Smales and Pate (1952) ¹⁶ |
| | | | | Ishibashi <i>et al.</i> (1951) ¹⁶ |

ANALYSIS

1. *Bromine*.—The bromine in sea-water was oxidised to bromate and determined iodometrically.⁵

2. *Strontium*.—After separation of Iron and Aluminium from sea-water (volume 5 litres) Ca^{++} and Sr^{++} were precipitated as oxalates and the oxalates converted to nitrates. From the mixed nitrates, strontium nitrate was extracted with alcohol and ether and then estimated as strontium sulphate.²

3. *Boron*.—The method depends on the fact that boric acid titrates as fairly strong acid

separated as cobaltinitrites. The precipitate was dissolved in hydrochloric acid and cobalt separated from the mixture as sulphide by passing H_2S gas. The filtrate was used for estimating rubidium after separation of NaCl and KCl using concentrated hydrochloric acid. Rubidium was precipitated by adding a boiling solution of 25% stannic chloride. The precipitate was filtered, washed with alcohol, dried at 120° C. and weighed as Rb_2SnCl_6 .⁷

6. *Silicon*.—Silicon was estimated colorimetrically by forming a yellow molybdenum complex with ammonium molybdate reagent in

presence of mineral acid.⁹ The colour developed with the sea-water sample was compared with that of the standard solutions in the range from 0 to 1.0 mg. silicon per litre.

7. *Lithium*.—100 litres of sea-water were evaporated down to 4 litres thereby separating the major portion of the constituents such as NaCl, CaSO₄, etc. From the concentrated brine (4 litres) magnesium was separated as magnesium carbonate. Lithium and the residual magnesium in the filtrate were precipitated together as phosphates and weighed as Li₃PO₄ + Mg NH₄ PO₄ · 6H₂O.⁸ Magnesium content from this mixture was estimated separately by EDTA titration and lithium content was calculated by difference from the mixed precipitate.

8. *Iron*.—100 ml. of sea-water were acidified with sulphuric acid and the solution evaporated to dryness. The residue was extracted with water and ferrous ions were oxidised and the ferric ion estimated colorimetrically using KCNS solution² (p. 486).

9. *Iodine*.—The method is based on the catalytic effect of the liberated iodine on the reduction of ceric salt by arsenious acid in sulphuric acid solution. The reduction is determined by arresting the reaction at a given time by the addition of excess of ferrous solution followed by thiocyanate solution. The red colour of ferric thiocyanate is measured colorimetrically at wavelength 488 mμ. The depth of this colour is inversely related to the iodide concentration⁶. The amount of iodine is deduced from a previously prepared calibration graph with solutions containing 0.01 to 0.1 mg. iodine per litre.

10. *Phosphorus*.—Total phosphorus content of sea-water was determined colorimetrically after the oxidation of organic phosphorus with perchloric acid.¹⁰ The phosphomolybdate complex colour was developed with ammonium molybdate and compared with standard solutions (range 0.0 to 100 microgram of P per litre).

11. *Copper*.—The method reported by Chow and Thompson¹² for colorimetric estimation of copper using diethyl dithiocarbamate as colour-forming agent was adopted.

12. *Aluminium*.—Aluminium content in 50 ml. sea-water was estimated colorimetrically

using 8-hydroxy-quinoline reagent and comparing the colour developed with the standard solutions in a Dubosq colorimeter⁹ (p. 26).

13. *Manganese*.—The method reported by Barnes¹¹ for colorimetric estimation of manganese from sea-water was used. Manganese in sea-water was oxidised to permanganate and the colour compared with standard permanganate solutions in the range 0.0 to 10 μgm. Mn per litre.

14. *Arsenic*.—One litre of sea-water was concentrated to 250 ml. Arsenic was estimated from this solution according to the method given in Analab standards for traces of arsenic in salt solutions.¹³ The stains produced on mercuric chloride paper were compared with stains produced from known amounts of arsenic.

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