

ESTIMATION OF FLUORIDE AND NITRATE IN GROUND WATERS OF ARID REGIONS OF RAJASTHAN USING ION SELECTIVE ELECTRODES

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ABSTRACT

Standard spectrophotometric methods are ineffective for the estimation of fluoride and nitrate in polluted/coloured samples of waters. For such waters, the method using ion-selective electrodes is more reliable, simple and rapid. Ground-waters of arid western Rajasthan containing high concentrations of chlorides, bicarbonates, sulphates and other dissolved salts were analysed for fluoride and nitrate contents by this method. In high fluoride waters, there existed positive linear relationship between F^- and HCO_3^- and negative relationship between F^- and $(Ca^{2+} + Mg^{2+})$. Concentration of Mg^{2+} was generally higher than that of Ca^{2+} in high fluoride waters.

INTRODUCTION

Ground-waters in arid regions of Rajasthan are generally brackish and may have salinity (as NaCl) upto 10,000 mg/l (Ram Gopal and Ghosh, 1984). Only 9% of the ground waters fall within potable limit of 500 mg/l of total dissolved salts laid down by WHO (1971) and ICMR (1975). Widely distributed anions in ground waters of Thar desert are HCO_3^- , Cl^- , SO_4^{2-} , NO_3^- and F^- . Fluoride and nitrate contents of water affect the public health.

In this paper we report the quality of ground waters in arid regions of Rajasthan with regard to fluoride and nitrate. Analyses of water samples from polluted ground water sources and industrial waste water were also carried out. Comparative studies of standard spectrophotometric and ion-selective electrode (ISE) methods in presence of naturally occurring interfering ions have been done and presented.

MATERIAL AND METHODS

Ground-water samples (200) were collected in polythene bottles from representative tube-wells, open-wells and hand-pumps in Jaisalmer, Barmer and Jodhpur districts. The polluted samples (50) were collected from industrial waste water and hand pumps located in the industrial areas in Jodhpur, Pali and Barmer. The physico-chemical parameters were estimated using standard analytical methods recommended by APHA (1985). Polluted water samples were also analysed for the presence of metal ions (zinc, lead, cadmium and copper), using standard methods of APHA (1985).

Nitrates were found in high concentrations and about 12% ground-waters recorded to have 100 mg NO_3^- /l and above (Table 1). The maximum concentration of NO_3^- in water was found to be 300 mg/l. Detailed studies undertaken by the authors (1983) on fluoride and nitrate levels in ground waters of arid areas of western Rajasthan have shown that these health affecting ions are wide-spread and seriously affect health of human-beings and cattle of this region.

The analysis of polluted water samples collected from industrial areas is given in Table 1. The concentrations of trace-metals, though less than the maximum permissible limits laid down by WHO, were higher than those present in natural unpolluted waters. The waters from hand-pumps situated in industrial areas also had higher values of these trace metals.

Fluoride and nitrate were estimated using ISE and also by spectrophotometry (Table 1). The fluoride estimation by two methods showed variation upto 0.5 mg/l in 67% samples, 0.6 to 1 mg/l in 19% samples and more than 1 mg/l variation in 14% of samples. The variation in high fluoride bearing water (F^- , 6.30 to 12.8 mg/l) was more significant. These waters were found to contain $\text{TDS} \leq 500$ mg/l, $\text{HCO}_3^- \leq 600$ mg/l and $\text{Cl}^- \leq 600$ mg/l. Fluoride is reported to form complexes with Al^{3+} , Fe^{3+} , Si^{4+} , Cl^- , Br^- , I^- , SO_4^{2-} , HCO_3^- , NO_3^- , PO_4^{3-} and hydrogen. HCO_3^- and Cl^- in high concentrations and CO_3^{2-} and SO_4^{2-} in somewhat lower concentrations in ground waters of arid areas and also the alkalinity interfere with F^- estimation by spectrophotometric method. Undissociated HF acid and HF_2^- ion in acid medium in spectrophotometric determinations also interfere (Srinivasan and Rechitz, 1968) causing large variations. However, in ISE method ISA used avoids complexation by hydrogen ion and hydroxyl ions by keeping the pH between 5 to 5.5. The CDTA used in ISA complexes interfering cations and decomplexes fluoride. The laboratory samples deliberately added with higher HCO_3^- , Cl^- and SO_4^{2-} ions also exhibited similar behaviours, showing interference when estimations were made by spectrophotometric method.

The fluoride bearing ground-waters were found to have positive linear relationship with HCO_3^- . In general ground waters of arid regions with F^- upto 4 mg/l contained HCO_3^- ranging from 200 to 600 mg/l. A few water samples with TDS around 5000 mg/l and F^- 8 to 12.8 mg/l were found to contain HCO_3^- as high as 1200 to 1505 mg/l.

A negative relationship existed between F^- and $\text{Ca}^{2+} + \text{Mg}^{2+}$. Generally Ca^{2+} are present from 200 to 50 mg/l concentrations in waters having F^- from 2 to 12.8 mg/l. In comparison to Ca^{2+} , Mg^{2+} has been found in high concentrations in the region.

Variation in nitrate determinations by two methods were mainly due to presence of high concentrations of Cl⁻ and HCO₃⁻. Carbonates and bicarbonates were removed by acidifying the samples (pH 4 to 4.5) and excess Cl⁻ was removed by addition of Ag₂SO₄. The interference is made insignificant by addition of ISA, 2M (NH₄)₂SO₄ maintains constant background ionic strength during measurement with ISE. The variations in ISE and brucin spectrophotometric methods at such low levels has been found to be less than 5 mg/l in 67% samples. However, coloured polluted water samples could not be tested for presence of either F⁻ or NO₃⁻ by spectrophotometric methods.

CONCLUSIONS

Estimation of fluoride and nitrate by ion-selective electrodes is more reliable, simple and rapid. Detailed hydrogeological, biochemical, epidemiological and physiological studies are required to generalise above correlation between fluoridated waters on human health. The milk and other food-stuffs like meat, cereals, vegetables, fruits etc. obtained from this region are also required to be systematically studied to control excessive F⁻ intake.

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