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Original Research Paper

Analysis of Fluoride Ion Concentration From Salt Pans of Marakkanam, Villupuram District, Tamil Nadu

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ABSTRACT

Fluorine is an important trace element that forms fluoride compounds. Fluoride as salt is known for both positive and negative effects on human health. Deficiency of fluoride leads to dental caries and excess causes a severe disease called fluorosis. Intake of fluoride rich food is also responsible for fluorosis. WHO recommendation for the permissible limit of fluoride is 1.5 mg/L. The saline water and salt samples collected from Marakkanam, Villupuram District were studied with special reference to the fluoride content. The samples were drawn in the pre-monsoon period comprising eight days during May 2011. The findings revealed that the concentration of fluoride was between 0.9 mg/L and 1.4 mg/L, which is within the permissible limits. The concentration of fluoride ion increased in the salt water till the start of crystallization, which subsequently decreased with an increase in salt formation.

INTRODUCTION

Fluorine exists in the form of fluoride along with a number of minerals of which fluorspar, cryolite and fluorapatite are common (Prabavathi Nagarajan et al. 2004). Fluorine not only exists in rocks such as igneous and sedimentary but also in water in varied amounts and in many other organisms. Generally, the fluoride content in water is not dangerous to humans, but in some cases weathering of rocks, especially volcanic rocks, add on the fluoride ions (Lucas 1988). Saline water and salts obtained from salt pans definitely contain fluoride and other ions. Normally, the level of fluoride in sea water is 0.5 to 1.4 mg/L (Ayoob & Gupta 2006). Fluoride as salt is known for its positive and negative effects on human health. They can interfere with carbohydrates, lipids, proteins, vitamins, enzymes and mineral metabolism when the dosages are high. In certain parts of India, the fluoride levels have also been below 0.5 mg/L, while in certain other places, fluoride levels have been as high as 35 mg/L (Handa 1975).

According to safe drinking water quality standards, the concentration of fluoride has to be between 0.6 and 1.0 ppm in potable water which protects tooth decay and enhances bone development (Kundu et al. 2001). The deficiency of fluoride leads to dental caries and excess of it causes a severe disease called fluorosis. It is clear from scientific findings that the fluoride concentration should be below 1 ppm which is beneficial for the prevention of dental caries or tooth decay. Above 1.5 ppm, the severity of fluorosis increases (WHO 2006, ISI 1983). In India, 80% of the rural areas and 50% of the urban areas are met with threat due to excess fluoride problems (Fejerskov et al. 1990). It is also a well known fact that the intake of excess fluoride beyond a limit (1.5 mg/L) leads to dental and skeletal fluorosis which is of serious public health concern world wide (WHO 1984). Dental fluorosis is usually endemic in nature (Fejerskov et al. 1990). Although the presence of optimum levels of fluoride for the prevention of dental caries are reformed, excessive fluoride intake for a long period can affect teeth of human and also in animal system. Unlike dental fluorosis, skeletal fluorosis is not clinically obvious until the advanced stage of crippling fluorosis occurs (Fig. 1).

Food has also been identified as a main source of fluoride. One extreme example is the prevalence of dental fluorosis among the native people of South Atlantic Island who consume water with only 0.2 ppm fluoride but fish with high levels of fluoride (7 mg/kg) (Apparao & Karthikeyan 1986).

The oceans are an important source of sodium chloride accounting to nearly 50% of the world production today. Of the annual production, only 6% is directly used for edible purposes. Sodium chloride is used as an important raw material for many industries as it is cheap and are widely distributed in nature as rock salt or halite and brine (Agarwal 1956). Though seawater is said to contain mainly sodium chloride, it is an important source for potassium, magnesium and bromine. 65% of the magnesium metal and 68% of bromine produced in the world are from sea (Bonython 1964). One litre of seawater contains 35 grams of the dissolved salt giving it a specific gravity of 1.034. This value is variable within a small range. Salt in solid state is a non-conductor of electricity, but in liquid form it becomes a good ionic conductor of electricity. In general, the presence of 35 grams of salt in 1 litre of water, makes it a very good electrical conductor but on salt formation the electrical conductivity decreases.

MATERIALS AND METHODS

The saline water and salt samples were collected from Marakkanam of Villupuram District, Tamil Nadu. The sea water salt pans cover an area of 3250 acres. The samples were collected daily during the pre-monsoon season (May 2011) from the salt pan for a period of 8 days in clean 1-litre capacity polythene bottles from 14-05-2011 to 21-05-2011. The sample bottles were first rinsed with de-ionised water and then for two to three times with the water samples before collecting it for analysis. The concentration of the saline water in a pan gradually increases due to evaporation and finally it becomes the salt. After the saline water was released from the reservoir pond, the salt got crystallized on the 8th day. The crystallized, solid salt sample was also collected in a clean polythene container. For analysing the salt, the salt was converted into a saturated solution by dissolving 390 g salt in 1 litre of de-ionised water. Pan soil was collected by inserting a PVC pipe of 2 feet length into the soil. For analysing the soil, 470g pan soil was dissolved in 1-litre of de-ionised water.

Determination of Fluoride

Preparation of the reagent: 70 mg of alizarin red S was dissolved in 50 mL of distilled water. 300 mg of zirconyl chloride octa hydrate was dissolved in 50 mL of distilled water. The alizarin red S solution was poured slowly into zirconyl chloride solution. After few minutes the solution became clear. This was called as first solution. To 101 mL of concentrated hydrochloric acid, distilled water was added and the volume made up to 400 mL. 33.3 mL of the concentrated sulphuric acid was added to 400 mL of distilled water and hydrochloric acid mixture. The mixture was cooled. The first solution was mixed with the second solution. This mixture was made up to 1000 mL in a 1-litre flask.

Analysis of fluoride: 100 mL of sample or a portion of sample was taken and diluted to 100 mL in a Nessler cylinder. 5 mL of acid-zirconyl alizarin reagent was added and kept in dark. The colour standards were compared after one hour. The volume of standard fluoride, which was used for comparing the colours was noted.

$$\text{Fluoride (ppm)} = \frac{\text{Standard fluoride in mL} \times 50 \times 100}{\text{Sample in mL}}$$

Fig. 1: Bones affected by skeletal fluorosis.

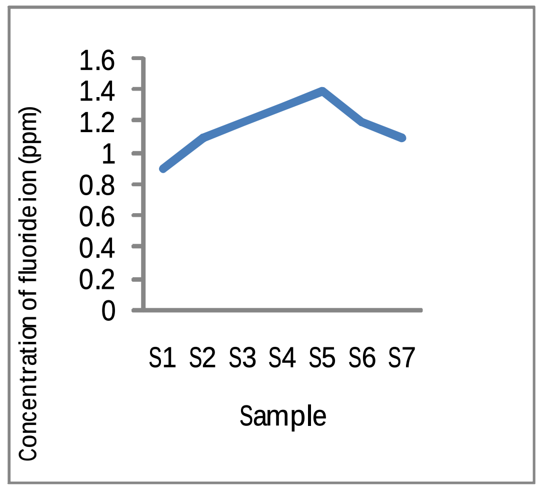

Fig. 2: Fluoride concentration in pan water samples during crystallization stages.

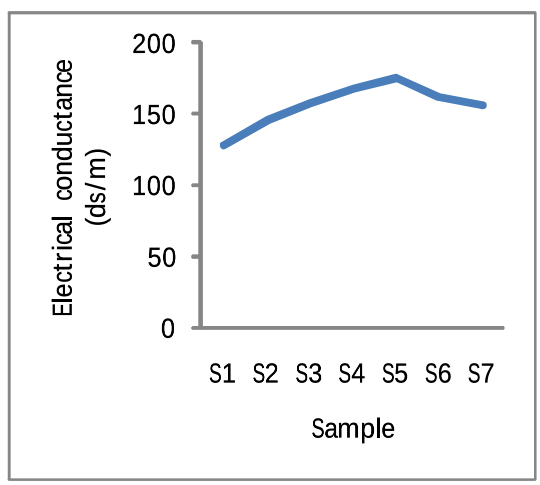

Fig. 3: Electrical conductivity of pan water samples during the varied stages of crystallization.

Table 1: Analysis of fluoride ion concentration and electrical conductivity in pan water samples, salt and pan soil.

Sample No.	Date of collection	Concentration of Fluoride (ppm)	Electrical conductance (dS/m)
S1	14-05-2011	0.9	128
S2	15-05-2011	1.1	146
S3	16-05-2011	1.2	157
S4	17-05-2011	1.3	167
S5	18-05-2011	1.4	175
S6	19-05-2011	1.2	162
S7	20-05-2011	1.1	156
S8	21-05-2011	1.0	153
S9	21-05-2011	1.0	172

S_1-S_7 indicates saline samples; S_8 indicates salt sample; S_9 indicates pan soil sample.

Determination of electrical conductance: Electrical conductance of the water samples was determined by conductivity meter (Systronics). The conductivity meter was calibrated using 0.01 N KCl solution at 25°C. The conductivity cell was washed free of KCl solution by distilled water and finally with the respective samples. The electrical conductance of the different saline water samples was measured at 25°C.

RESULTS AND DISCUSSION

The fluoride ion concentration and electrical conductivity of the saline samples, salt and soil that were estimated/measured are given in Table 1.

The amount of fluoride ion present in the pan water samples was analysed till the crystallization stage and is presented in Fig. 2. During the initial stage, the concentration of fluoride ion was low and with the progression of sample collection from salt pan daily it increased slowly (0.9 mg/L to 1.4 mg/L). The higher value of fluoride content gradually declined with the formation of salt during the crystallization process (1.4 mg/L to 1.0 mg/L).

During the crystallization process considerable amount of fluoride get settled in the pan soil, which was detected to be 1.0 mg/L. The level of fluoride ion concentration in the various samples collected was also supported aptly by electrical conductivity studies which are portrayed in Fig. 3.

The electrical conductivity of the samples measured candidly reflected a gradual increase reaching the highest value of 175 dS/m which decreased subsequently (153 dS/m). However, on testing the pan soil, a higher E.C. value (172 dS/m) was recorded which could be attributed to the existence of other ions that include both cations and anions.

CONCLUSION

It is extrapolated from the foregoing works that salt has fluoride ion content under permissible limits (I.S.I. standards). It is also construed that the saline waters of Marakkanam have high level of fluoride initially but on crystallization the salt proceeds to possess only limited content of fluoride making it conducive for human consumption and avoid fluorosis from health view point.

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