

# The accuracy of fluoride measurement in water and its implications for water fluoridation

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## Abstract

The accurate measurement of the fluoride concentration in water is an essential prerequisite to stay within the allowable dosing tolerances required by the South African water fluoridation legislation. In the absence of reliable error estimates for fluoride measurement in natural water samples, a study was conducted utilising data from interlaboratory comparison studies conducted by the CSIR, the SABS and MEDUNSA. This study shows that:

- natural samples are more difficult to measure than synthetic samples;
- technology advances over the last 25 years did not reduce the measurement error significantly;
- all analytical methods suffer to some extent when natural samples are analysed; and
- the measurement error will have to be appreciably reduced if the legal requirements of the pending water fluoridation are to be met.

**Keywords:** Water fluoridation, fluoride measurement, accuracy, measurement error, natural samples, synthetic samples

## Introduction

South Africa is poised for the mandatory fluoridation of drinking water up to a general target concentration of 0.7 mg F/l. This often emotional issue had been debated during years of preparation of draft legislation, until the approval of the final regulations by Parliament and their promulgation in September 2001. The attention of the water industry has therefore moved to the many smaller but important technical issues of practical implementation. One of the obvious keystones of water fluoridation is the ability to measure the fluoride concentration in water – firstly for determining how much supplementation is required, and secondly for checking that the target is reached within the allowable tolerances. This paper thus directs its attention to the measurement of fluoride in water; a vital, difficult aspect of water fluoridation which has seemingly been overlooked.

## Dosing accuracy legally required in SA

The SA Regulations (*Government Gazette*, 2001) are explicit in their requirements for dosing accuracy, thereby closely following similar UK regulations. The first stipulation is:

- Instantaneously measured fluoride concentration must be within 0.2 mg/l of the target.

The fluoridation plant operator therefore has to measure the fluoride concentration in the raw water; measure the water flow rate; calculate the fluoride dosing rate to make up the shortfall towards the target concentration; and check the procedure by measuring the fluoride concentration in the fluoridated water. For the purposes of

this paper, assume that there are no calculation errors, that the water flow rate and the fluoride solution strength in the day tank are exactly known, and that the fluoride dosing pump can be set with absolute accuracy. The only error to consider is therefore the error due to the measurement of the fluoride concentration before and after dosing.

It is obvious that any measurement error will be compounded during the required feedback loop. This is illustrated by the following example, where a constant under-measurement error of 30% is assumed for illustration:

- The raw water fluoride concentration is actually 0.20 mg/l, but measured as 0.14 mg/l. The shortfall is therefore actually 0.50 mg/l below the target level of 0.70 mg/l, but perceived by the operator to be 0.56 mg/l.
- The dosing pump is set to add 0.56 mg/l, resulting in an actual concentration of 0.76 mg/l or 0.06 mg/l above the target. The operator measures this as 0.53 mg/l and still perceives a shortfall of 0.17 mg/l.
- The operator, correctly, increases the dosing rate by 0.17 mg/l to get an actual concentration of 0.93 mg/l, which is still perceived as 0.65 mg/l or 0.05 mg/l short of the target.
- This cycle continues until the concentration stabilises at the perceived target concentration. By this time, the actual concentration is about 1.00 mg/l, or about a 40% overdose.

As an apparent independent check on the dosing accuracy, the SA Regulations further stipulate that:

- Average dosage over a week must be within 0.1 mg/l of the target.

The fluoridation operator should check this requirement by a careful site inventory of on-site fluoridation chemicals and the volume of water fluoridated since the previous check. (It should