Technical note

Geographical differences in the relationship between total dissolved solids and electrical conductivity in South African rivers

H van Niekerk*, MJ Silberbauer and M Maluleke
Resource Quality Services, Department of Water Affairs, Private Bag X313 Pretoria, South Africa

ABSTRACT

Electrical conductivity (EC) is a useful surrogate for total dissolved solids (TDS). EC is more rapidly and easily measurable with reasonably-priced equipment. However, as an indirect measure EC is subject to uncertainties that are not always apparent to the user. We set out to investigate the relationship between TDS and EC in 144 643 sample results available on the Department of Water Affairs water quality database. TDS is calculated as the sum of the major solutes determined by laboratory analysis and EC is a measurement in a flow cell. The median TDS:EC ratio for 332 high priority sites was 7 mg/ℓ: 1 mS/m. Regional differences ranged from 4.8 to 8.6. Investigation of 38 of these sites using Maucha diagrams suggested that the differences are related to the dominant major ions, with sodium chloride waters having a lower TDS:EC conversion factor than calcium bicarbonate waters. The practical application of these findings is that users of EC meters should not simply apply a blanket conversion factor, but need to select an applicable factor for the river system in which they are measuring.

Keywords: conversion factors, electrical conductivity, field instruments, rivers, total dissolved solids, water quality

INTRODUCTION

Many water sector analysts routinely use total dissolved solids or salts (TDS) as a measure of water salinity. User agencies include agriculture, industry, water supply, mining and resource management. Guidelines or resource objectives for TDS help to maintain optimum production in each sector.

The units of measurement for TDS are usually milligrams per litre (mg/ℓ), grams per litre (g/ ℓ) parts per million (ppm) or parts per thousand (ppt or $^{o}/_{oo}$). Direct methods for determining TDS concentration are gravimetric, for example evaporation at 180°C (APHA, 1999), flow densitometry or determination of the major individual solutes by laboratory analysis and their algebraic summation (APHA, 1998). These methods are expensive and time consuming, and a much cheaper, easier and quicker method to infer TDS concentration is by measuring electrical conductivity (EC) using an EC meter and converting the value to TDS with a constant conversion factor. The use of EC to determine TDS in water is based on the principle that pure water is a poor conductor of electricity and the ability to conduct electricity increases linearly with increasing ion concentration. The TDS:EC ratio for natural inland waters varies from 5.4 to 9.6 mg/ℓ per mS/m, depending on the ionic composition and strength of the solution being tested, so that water containing mainly NaCl will have a ratio closer to 5, while water with a high sulphate content may have a ratio as high as 9.6 (Hem, 1985). Groundwater TDS:EC ratios in South Africa vary from <6 in the south-west to >8 in the north-east (Simonic, 2000). The South African Water Quality Guidelines assume a general conversion factor (CF) of 6.5 for TDS:EC, although it is recommended by the Guidelines that site-specific CFs be used where more accurate TDS concentrations are required (DWAF, 1996).

Many EC meters and loggers have an option to perform the conversion internally, presenting the user with a TDS reading that is no more than an estimate derived from the EC. The TDS:EC conversion factor may be based on measurement of a standard solution of, for example, KCl, or it may be the average of a number of TDS:EC ratios in samples where both measurements are known. South African water quality practitioners use this method extensively and the reliability of the approach, which we will refer to as the TDS:EC method, is the subject of this paper.

Although the TDS:EC method is capable of providing very accurate TDS concentrations, the use of a universal conversion factor can result in over- or underestimates. Users of EC meters need to follow certain basic procedures to ensure good representative TDS values, namely, proper calibration and maintenance, correct instrument use and application of the correct TDS:EC conversion factor. Personal observation of the activities of field personnel in the Department of Water Affairs suggests that instrument maintenance is acceptable but that personnel tend to apply the built-in TDS:EC conversion factor without consideration of the implications. Users of EC meters may assume that the standard instrument setting is correct, or they may not even be aware that an indirect measurement is taking place. Standard instrument settings for well-known conductivity meters used in South Africa vary between 5 and 7, depending on the make and model. An EC reading of 70 mS/m could therefore imply a TDS of 350 to 490 mg/ℓ, depending on the built-in conversion factor setting.

* To whom all correspondence should be addressed.
☎ +27 12 808 9502; fax: +27 12 808 0338;
e-mail: VanNiekerkH2@dwa.gov.za
Received 29 June 2012; accepted in revised form 9 January 2014.

http://dx.doi.org/10.4314/wsa.v40i1.16
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 40 No. 1 January 2014
ISSN 1816-7950 (On-line) = Water SA Vol. 40 No. 1 January 2014