Abstract

This work discusses simulative models of Ca and Mg complexation with natural organic matter (NOM), in order to control the incidence of scaling in pipes carrying cooling water at the Eskom power generating stations in South Africa. In particular, the paper reports how parameters such as pH and trace element levels influence the distribution of scaling species and their interactions, over and above mineral phase saturation indices. In order to generate modelling inputs, two experimental scenarios were created in the model solutions: Firstly, the trace metals Cu, Pb and Zn were used as markers for Ca and Mg complexation to humic acid and secondly the effect of natural organic matter in cooling water was determined by spiking model solutions. Labile metal ions and total elements in model solutions and water samples were analysed by square wave anodic stripping voltammetry and inductively coupled plasma optical emission spectrometry (ICP–OES), respectively. ICP–OES results revealed high levels of K, Na, S, Mg and Ca and low levels of trace elements (Cd, Se, Pb, Cu, Mn, Mo, Ni, Al and Zn) in the cooling water samples. Using the Tipping and Hurley's database WHAM in PHREEQC format (T_H.DAT), the total elemental concentrations were run as inputs on a PHREEQC code, at pH 6.8 and defined charge as alkalinity (as HCO_3^-) For model solutions, PHREEQC inputs were based on (i) free metal differences attributed to competitive effect of Ca and the effect of Ca + Mg, respectively; (ii) total Ca and Mg used in the model solutions and (iii) alkalinity described as hydrogen carbonate. Anodic stripping peak heights were used to calculate the concentration of the free/uncomplexed/labile metal ions (used as tracers) in the model solutions. The objective of modelling was to describe scaling in terms of saturation indices of mineral phases. Accordingly, the minerals most likely to generate scale were further simulated (over a range of pH (3–10) to yield results that mimicked changing pH. Speciation calculations of Cu^{2+}, Pb^{2+} and Zn^{2+} generated azurite, cerrusite and smithsonite mineral phases, which showed positive saturation indices at higher pH, hence increased potential to precipitate (form scale). The derived predictive models would act as a useful management tool and henceforth aid to avoid unnecessary costs due to the consequences of scaling.