

INVESTIGATION OF HEAVY METAL

SPECIATION

IN LAKE NAKURU

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By

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Abstract

The concentration of heavy metals in natural waters is normally too low for direct speciation studies. Therefore, special analytical techniques are required in order to avoid disturbing the natural concentrations. Voltammetry is one such technique that can be used due to its high sensitivity and selectivity. In this study, two voltammetric methods namely, Differential Pulse Anodic Stripping Voltammetry (DPASV) and amalgam Voltammetry (aM) have been used to study heavy metal speciation in model lake water at concentration levels of genuine lake water in KNO_3 at 23°C .

In the amalgam method, the hanging drop electrode was prepared *in situ* prior to exchanging the medium for the solution to be studied. Half-wave potentials at two metal ion concentrations were measured, one at the actual concentration in the lake while the other at a much lower one. The experimentally determined shifts in half-wave potentials are used to compute several metal complex formation constants. The study reveals the complex species that are present in the lake and a prediction is made of the distribution of the elements Cu, Pb, Cd and Zn over their major labile complex species existing.

The $[\text{CO}_3^{2-}]$ in the lake is quite high followed by $[\text{HCO}_3^-]$ and $[\text{Cl}^-]$. These ions, therefore, are the main contributors to the speciation of the heavy metals. The levels for OH^- and F^- are very low, hence, their contribution to the speciation of the metals is not quite significant. The different chemical forms present in the lake have been used to construct the pollution impact of heavy metals that may be introduced into the lake. For instance, hydroxo and fluoro complexes of Cu and Cd have free metal Cu^{2+} and Cd^{2+} ions

dominating while fluoro and bicarbonato complexes of Zn have free metal Zn^{2+} being dominant. For mixed complexes, OH^-/Cl^- and CO_3^{2-}/Cl^- for Cd and OH^-/Cl^- for Zn show the presence of free metal ions as dominant species. The presence of the free metal ions poses danger to the ecosystem due to toxicity. However, the CO_3^{2-}/Cl^- system for copper acts as a buffer since at the $[CO_3^{2-}] = 0.5$ M in the lake, no free Cu^{2+} ions exist, hence, there is no potential environmental danger posed.

There is a variation in the number of complexes formed, their stabilities and distribution comparing the two methods. In some cases, the DPASV system reveals the formation of more stable complexes than the amalgam, while in others, the amalgam shows more stabilization although with a tendency to form fewer complexes. Metal ion concentration also seems to play a role in determining the number of complexes formed and their stabilities. The two techniques agree in identifying a great limitation in complex formation for the copper systems OH^-/F^- , F^- and HCO_3^- .

Metal/mercury composition compound formation in the mercury drop in terms of dicomplex and dependence on second metal effect of the metal-amalgam has also been investigated by utilizing interaction of two metals in a hanging drop amalgam voltammetry in the Differential Polarography (DP) mode. Deposition time for the first metal was kept constant at 90 seconds while that for the second metal varied.

The results show that the order in which metals are introduced into the mercury drop is crucial in determination of the number of complexes formed with their varying stabilities. For example, the Cu-Zn system is destabilizing whereas Zn-Cu is quite stabilizing.

Generally, Cd complexes are the most stable with Zn-Cd, having formula $Zn_{30}Cd_1$, as the most stable one with K value of 34.57. However, Cu-Cd is the most destabilized system of them all. The results also show that the presence of CO_3^{2-} introduces extra stability and generally reduces the number of reacting atoms.