

EXECUTIVE SUMMARY

Generally, and particularly in South Africa, there has been limited work done on the development of methodologies for determination of sample size and quantifying uncertainties in geochemical sampling and analyses. This, in turn may result in lack of confidence in the long-term predictions of geochemical modeling for Environmental Risk Assessment (ERA) and problems in obtaining approval of mining authorizations, water use licenses and mine closure plans.

This report addresses this deficiency in geochemical sampling and analyses and proposes two methodologies: (i) for quantifying uncertainties in geochemical sampling and analysis as a function of sample size and analysis and (ii) for determining the optimum sample size to ensure data quality.

The statistical analysis approach was adopted as the best method for sample size determination. The approach is based on the premise that “the size of the study sample is critical to producing meaningful results”. The size of the required samples depends on a number of factors including purpose of the study, available budget, variability of the population being sampled, acceptable error and required confidence level.

The methodology for estimating uncertainty is a fusion of existing methodologies for quantifying measurement uncertainty. The methodology takes a holistic view of the measurement process to include all the processes involved in obtaining measurement results as possible components / sources of uncertainty. Like the statistical analysis approach, the methodology employs basic statistical principles in estimating the size of uncertainty associated with a given measurement result. The approach identifies each component of uncertainty; estimates the size of each component and sums the contribution of each component in order to approximate the overall uncertainty value associated with a given measurement result.

The two methods were applied to Acid-Base Accounting (ABA) data derived from geochemical assessment for Environmental Risk Assessment of the West Wits and Vaal River tailings dams undertaken by Pulles and Howard de Lange Inc. on behalf of AngloGold Ltd. The study was aimed at assessing and evaluating the potential of tailings dams in the two mining areas to impact on water quality and implications of this impact in terms of mine closure and rehabilitation.

Findings from this study show that the number of samples needed is influenced by the purpose of the study, size of the target area, nature and type of material, budget, tolerable error and the confidence level required, among other factors. Acceptable error has an inverse relationship with sample size; confidence level and standard deviation have a positive correlation with sample size hence one can minimize error by increasing sample size. While a low value of acceptable error value and high confidence are always desirable, a trade-off among these competing factors must be found, given the fact that funds and time are normally limited.

The findings also demonstrated that uncertainties in geochemical sampling and analysis are unavoidable. They arise from the fact that only a small portion of the population rather than a census is used to derive conclusions about certain characteristics of the target population. This is further augmented by other influential quantities that affect the accuracy of the estimates. Effects such as poor sampling design, inadequate sample size, sample heterogeneity and other factors highly affect data quality and representivity, hence measurement uncertainty. Among these factors associated with sampling, heterogeneity was found to be the strongest contributing factor toward overall uncertainty. This implies an increased proportion of expenditure should be channelled toward sampling to minimize uncertainty.

Uncertainties can be reduced by adopting good sampling practices and increasing sample size, among other methods.