% respectively. The standard error was evaluated using Microsoft Excel version 2003.

Correlation (CORREL)
The correlation coefficient between lead yield and ferric nitrate concentration were evaluated from the results of the derived model and experiment, considering the coefficient of determination R2 from Figures 2 and 3. The evaluation was done using Microsoft Excel version 2003.

$$R = \sqrt{R^2} \quad (4)$$

The evaluated correlations are shown in Table 3. These evaluated results indicate that the derived model predictions are significantly reliable and hence valid considering its proximate agreement with results from actual experiment.

Table 3: Comparison of the correlations evaluated from derived model predicted and ExD results based on ferric nitrate concentration

Analysis	Based on ferric nitrate conc.	
	ExD	D-Model
CORREL	0.9812	1.0000

Graphical Analysis

Comparative graphical analysis of Figure 3 show very close alignment of the curves from the experimental (ExD) and model-predicted (MoD) lead yields.

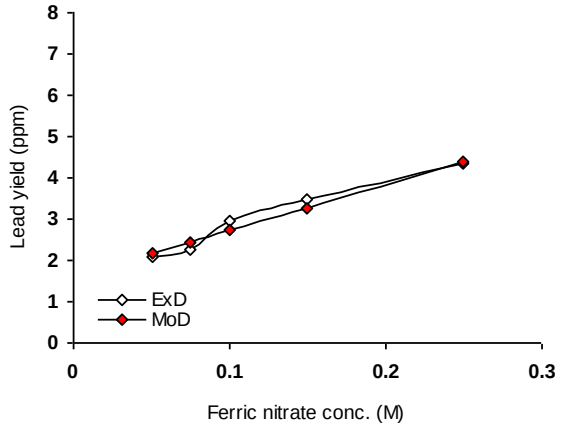

Figure 3: Comparison of lead yields (relative to ferric nitrate concentration) as obtained from experiment and derived model

Furthermore, the degree of alignment of these curves is indicative of the proximate agreement between both experimental and model-predicted lead yields.

Computational Analysis

Computational analysis of the experimental and model-predicted lead yield was carried out to ascertain the degree of validity of the derived model. This was done by comparing lead yield per unit ferric nitrate concentration using experimental and model-predicted results.

Lead yield per unit ferric nitrate concentrate

The lead yield per unit ferric nitrate concentration ξ_C was calculated from the expression;

$$\xi_C = \frac{\Delta\xi}{\Delta\varphi} \quad (5)$$

Equation (5) is detailed as

$$\xi_C = \frac{\xi_2 - \xi_1}{\varphi_2 - \varphi_1} \quad (6)$$

Where

$\Delta\xi$ = Change in lead yield at two different ferric nitrate concentrations φ_2, φ_1.

Considering the points (0.05, 2.08) & (0.25, 4.33), and (0.05, 2.172) & (0.25, 4.372) as shown in Figures 1 and 2, and designating them as (ξ_1, φ_1) & (ξ_2, φ_2) for experimental and derived model predicted results respectively, and then substituting them into equation (6), gives the slopes: 11.25 and 11.0 ppm/M as lead yield per unit ferric nitrate concentration respectively.

Deviational Analysis

The deviation Dv, of model-predicted lead yield from the corresponding experimental result was given by

$$Dv = \left[\frac{\xi_{MoD} - \xi_{ExD}}{\xi_{ExD}}\right] \times 100 \quad (7)$$

Where

ξ_{ExD} and ξ_{MoD} are lead yields from experiment and derived model respectively.

Critical analysis of the lead yield obtained from experiment and derived model shows low deviations on the part of the model-predicted values relative to values obtained from the experiment. This is attributed to the fact that the surface properties of galena and the physico-chemical interactions between the galena and the leaching solution which played vital roles during the leaching process were not considered during the model formulation. This necessitated the introduction of correction factor, to bring the model-predicted extracted lead concentration to those of the corresponding experimental values.

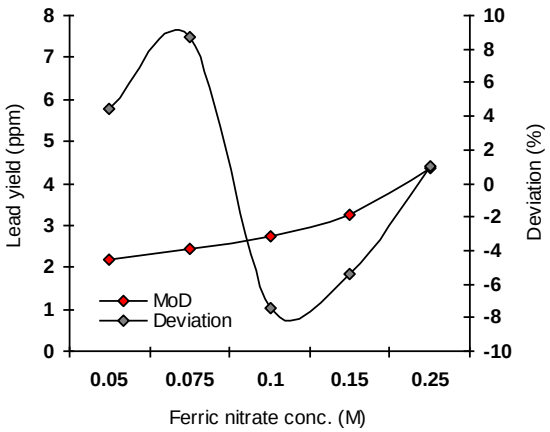

Figure 4: Variation of deviation with lead yield (relative to the ferric nitrate concentration)

Deviational analysis from Figure 4 indicates that the maximum deviation of model-predicted lead yield from the experimental results is less than 9%. This translates into over 91% operational confidence and response level for the derived model as well as over 0.91 response coefficient of lead yield to the combined operational contributions of the ferric nitrate concentration and reaction time.

Consideration of equation (7) and critical analysis of Figure 4 show that the least and highest magnitudes of deviation of the model-predicted lead yield (from the corresponding experimental values) are + 0.97 and + 8.76. Figures 1-4 indicate that these deviations correspond to lead yields: 4.372 and 2.447 ppm as well as ferric nitrate concentrations: 0.25 and 0.075 M respectively.

Correction factor, Cf to the model-predicted results is given by

$$Cf = -\left[\frac{\xi_{MoD} - \xi_{ExD}}{\xi_{ExD}}\right] \times 100 \qquad (8)$$

Critical analysis of Figures 1-5 indicates that the evaluated correction factors are negative of the deviation as shown in equations (7) and (8).

The correction factor took care of the negligence of operational contributions of the surface properties of the galena and the physico-chemical interactions between the galena and the leaching solution which actually played vital role during the leaching process. The model predicted results deviated from those of the experiment because these contributions were not considered during the model formulation. Introduction of the corresponding values of Cf from equation (8) into the model gives exactly the corresponding experimental values of lead yield.

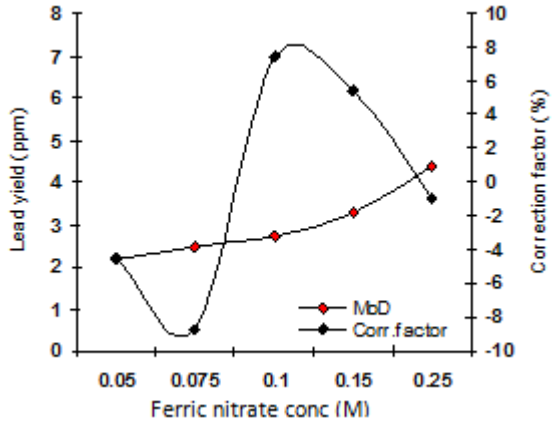

Figure 5: Variation of correction factor with lead yield (relative to the ferric nitrate concentration)

Figure 5 shows that the least and highest correction factor (to the model-predicted lead yield) are -0.94 and – 8.76%. Since correction factor is the negative of deviation as shown in equations (7) and (8), Figures 1-5 indicate that these highlighted correction factors correspond to lead yields: correspond to lead yields: 4.372 and 2.447 ppm as well as ferric nitrate concentrations: 0.25 and 0.075 M respectively.

It is very pertinent to state that the deviation of model predicted results from that of the experiment is just the magnitude of the value. The associated sign preceding the value signifies that the deviation is a deficit (negative sign) or surplus (positive sign).

5. Conclusion

Evaluation of lead yield during processing of galena in ferric nitrate solution was carried out based on input parameters such as ferric nitrate concentration and reaction time. The validity of an empirical model derived, validated and used for the evaluation was rooted on the expression $\xi = 11.0\varphi + 0.0011\chi + 1.60$ where both sides of the expression are correspondingly approximately equal. Statistical analysis of the lead yield for each value of the input ferric nitrate concentration as obtained from experiment and derived model-predicted results show standard errors 0.2051 and 1.2167×10^{-8} % respectively. Result evaluations indicate that lead yield per unit ferric nitrate concentration as obtained from experiment and derived model-predicted results were 11.25 and 11.0 ppm/ M respectively. The maximum deviation of the model-predicted lead yield (from experimental results) was of less than 9%. This implies a derived model confidence level above 91% as well as over 0.91 response coefficients for lead yield dependence on the ferric nitrate concentration and reaction time.

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