Data in Brief

This article provides data regarding the performance of zinc sulphate as a coagulant for treating rubber industry wastewater. The effect of four factors on removal efficiency of nine parameters is investigated, namely: pH, mixing speed, dosage of coagulant (zinc sulphate) and retention time. Response surface methodology was used to investigate the effect of selected variables. The data obtained from face centered composite design (FCCD) were analyzed by using analysis of variance (ANOVA) and regression model to find the optimum operating conditions for the selected factors.

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Specifications Table

| Subject area               | Environmental engineering |
|----------------------------|----------------------------|
| More specific              | Industrial wastewater treatment |
| Type of data               | Table and figure |
| How data was acquired      | Laboratory experiments and site sampling |
| Parameters for data collection | Wastewater sample collection, laboratory analysis, coagulant materials, coagulation using jar test |
| Description of data collection | Different dosages of zinc sulphate, pH, time and mixing speed, the physiochemical parameters are chemical oxygen demand (COD), total suspended solid (TSS), ammoniacal nitrogen (NH3-N), color and heavy metals (Pb, Fe, Zn, Cu, K) |
| Data Source location       | University of Kuala Lumpur, Malaysian Institute of Chemical and Bio Engineering Technology (UniKL-MICET), Melaka, Malaysia. Gloves manufacturing company (Tan Sin Lian Industries Sdn. Bhd), Lot 179-184, Alor Gajah Industrial Estate (Phase III), Jalan Industri 7, Alor Gajah, 78000 Melaka, Malaysia. 2°21′43.5″N 102°12′17.6″E |
| Data accessibility         | Within this article |
| Related research article   | Tawfiq J. H. Banch, Marlia M. Hanafiah, Abbas F. M. Alkarkhi, Salem S. A. Amr, Nurul U. M. Nizam, (2020). Evaluation of Different Treatment Processes for Landfill Leachate Using Low-Cost Agro-Industrial Materials. Processes, 8, 111; 1-12, [1]. https://doi.org/10.3390/pr8010111 |

Value of the Data

- The data produced an efficient method for rubber wastewater treatment using zinc sulphate as a coagulant.
- The data has benefits for rubber industries to manage their wastewater effluents. Also the data provides significant knowledge and applications to the university postgraduate students and research centres.
- The data provides model that can be used for treatment of several types of industrial wastewater treatment.

1. Data Description

The raw data for thirty experiments using face centered composite design (FCCD), [2] covering all possible combinations of the selected variables (Dosage of zinc sulphate (A), pH (B), retention time (C) and mixing speed (D)) regarding measuring physiochemical parameters such as chemical oxygen demand (COD), total suspended solid (TSS), ammoniacal nitrogen (NH3-N), color and heavy metals (Pb, Fe, Zn, Cu, K) for rubber wastewater are presented in Table 1. The results of the experiments were analyzed using analysis of variance (ANOVA) [3]. The independent variables (factors) and corresponding levels used for optimization of rubber wastewater treatment is summarized in Table 2. The three-dimensional response surface curves and their effect on TSS, COD, Color, Ammonia heavy metals are presented in Figs. 1 and 2. Interaction curves showing the behavior of two factors on the effect of TSS, COD, Color, Ammonia and heavy metals are presented in Figs. 3 and 4. The significance of the influential variables is presented in Table 3 and 4 (analysis of variance (ANOVA)). Mathematical models that show the effect of significant variables on selected parameters are presented in Table 5 and 6 respectively. The equations of coded factors for TSS, COD, Color, ammonia and heavy metals removal were presented in Tables 5 and 6, respectively.
Table 1
The results of CCD including input variables and nine responses using zinc sulphate for treating rubber wastewater.

| A = Dosage of zinc sulfate | B = pH time | C = Retention speed | D = Mixing speed | TSS | COD | Color | Ammonia Fe | K | Pb | Cu | Zn |
|---------------------------|-------------|---------------------|------------------|-----|-----|-------|------------|----|----|----|----|
| 11                        | 7           | 60                  | 175              | 0.001 264 | 98 | 55 | 1.206 1.034 | 0.2401 | 0.013 | 7.001 |
| 7                         | 9           | 90                  | 250              | 0.002 143 | 27 | 27.8 | −0.052 1.099 | −0.046 | 0.001 | 0.624 |
| 11                        | 7           | 60                  | 250              | 0.001 228 | 43 | 15.8 | 1.324 1.261 | 0.2907 | 0.013 | 7.394 |
| 7                         | 9           | 90                  | 100              | 0.006 369 | 69 | 112 | 0.013 0.9788 | 0.032 | 0.001 | 1.079 |
| 15                        | 5           | 90                  | 100              | 0.005 169 | 68 | 50.4 | 0.01 0.9632 | 0.069 | 0.001 | 2.755 |
| 15                        | 9           | 90                  | 100              | 0.006 186 | 46 | 30.24 | 0.011 0.9359 | 0.05 | 0.002 | 1.331 |
| 11                        | 7           | 30                  | 175              | 0 252 | 92 | 9.52 | 0.013 0.9012 | 0.012 | −0.005 | 2.494 |
| 7                         | 5           | 30                  | 250              | 0.015 155 | 37 | 105.84 | 0.011 1.171 | 0.063 | 0.002 | 2.469 |
| 15                        | 9           | 30                  | 250              | 0.002 155 | 64 | 25.2 | 0.012 1.036 | 0.015 | −0.002 | 1.089 |
| 11                        | 9           | 60                  | 175              | 0.005 228 | 30 | 25.2 | 1.378 1.135 | 0.2239 | 0.001 | 0.2597 |
| 15                        | 5           | 30                  | 100              | 0.001 634 | 142 | 3.36 | −0.034 0.9831 | 0.034 | 0.004 | 2.551 |
| 11                        | 7           | 60                  | 175              | 0 255 | 90 | 60.3 | 1.212 1.027 | 0.2342 | 0.013 | 7.012 |
| 15                        | 7           | 60                  | 175              | 0.007 204 | 34 | 130.5 | 1.542 1.037 | 0.288 | 0.011 | 7.868 |
| 7                         | 9           | 30                  | 100              | 0.003 490 | 14 | 5.6 | 0.027 1.024 | 0.017 | 0.003 | 1.1 |
| 11                        | 7           | 60                  | 175              | 0.001 249 | 95 | 57.1 | 1.222 1.019 | 0.24 | 0.012 | 6.987 |
| 7                         | 9           | 30                  | 250              | 0 199 | 24 | 75.6 | 0.009 1.098 | 0.036 | −0.001 | 2.163 |
| 7                         | 7           | 60                  | 175              | 0.002 206 | 31 | 35.28 | 1.271 1.126 | 0.1383 | 0.012 | 6.86 |
| 7                         | 5           | 90                  | 250              | 0.001 213 | 8 | 90.72 | −0.054 1.092 | 0.039 | 0.004 | 2.369 |
| 15                        | 9           | 90                  | 250              | 0.002 201 | 26 | 443.52 | −0.057 1.239 | −0.005 | 0.004 | 0.741 |
| 11                        | 7           | 60                  | 175              | 0.001 263 | 88 | 50.7 | 1.221 1.043 | 0.2319 | 0.013 | 7.213 |
| 7                         | 5           | 30                  | 100              | 0.001 632 | 354 | 19.04 | −0.04 0.9499 | −0.004 | 0.007 | 2.378 |
| 11                        | 5           | 60                  | 175              | 0.001 224 | 50 | 25.2 | 1.396 1.195 | 0.2028 | 0.012 | 6.767 |
| 15                        | 5           | 30                  | 250              | 0.001 180 | 186 | 55.44 | 0.009 1.07 | 0.07 | −0.002 | 2.69 |
| 15                        | 5           | 90                  | 250              | 0.001 252 | 54 | 30.24 | −0.051 1.043 | −0.022 | 0.003 | 2.57 |
| 15                        | 9           | 30                  | 100              | 0.018 542 | 10 | 39.2 | −0.04 1.008 | −0.001 | 0.004 | 2.164 |
| 11                        | 7           | 90                  | 175              | 0 229 | 70 | 12.32 | 0.008 0.7462 | 0.027 | −0.005 | 2.539 |
| 11                        | 7           | 60                  | 175              | 0.002 236 | 57 | 19.6 | −0.019 0.8421 | 0.014 | 0.003 | 2.375 |
| 7                         | 5           | 90                  | 100              | 0.007 182 | 52 | 40.32 | 0.002 0.9582 | 0.033 | 0.002 | 2.46 |
| 11                        | 7           | 60                  | 175              | 0.001 256 | 96 | 61.7 | 1.211 1.101 | 0.2329 | 0.013 | 6.721 |
| 11                        | 7           | 60                  | 175              | 0.002 263 | 97 | 54.5 | 1.209 1.023 | 0.2331 | 0.013 | 6.81 |

Table 2
Independent variables (factors) and corresponding levels used for optimization.

| Variables                  | Symbol | Low level | Center | High level |
|----------------------------|--------|-----------|--------|------------|
| Coded                      | −1     | 0         | 1      |
| Zinc Sulfate dosage        | A      | 7 ml      | 11 ml  | 15 ml      |
| pH                         | B      | 5         | 7      | 9          |
| Reaction time              | C      | 30        | 60     | 90         |
| Mixing speed (rpm)         | D      | 100       | 175    | 250        |

2. Experimental Design, Materials and Methods

2.1. Sampling

20 l sample of rubber wastewater was collected from Tan Sin Lian Industries Sdn. Bhd, one of the gloves manufacturing companies that located in Kawasan Perindustrian Melekek, Alor Gajah, Malaysia. This company is a global glove manufacturing that operates for the past ten years. The sample was collected directly from production factory during the period between April and June 2019. Then, the sample was stored in the sealed plastics bottles and preserved at a temperature less than 4 °C before being used and analyzed. Then the sample was characterized following standard methods for water and wastewater analysis [4].
### Table 3

Analysis of variance for TSS, COE, Color and ammonia removal

|          | Sum of Mean F | Source Squares DF | Square Value | Prob > F |
|----------|---------------|-------------------|--------------|----------|
| **TSS**  | Source Squares DF | Square Value | Prob > F |          |
| Model 2.769E-004 | 14 | 1.978E-005 | 3.35 | 0.0133 |
| A 1.985E-005 | 1 | 1.985E-005 | 3.36 | 0.0868 |
| B 3.254E-005 | 1 | 3.254E-005 | 5.50 | 0.0331 |
| C 4.356E-007 | 1 | 4.356E-007 | 0.074 | 0.7897 |
| D 8.756E-005 | 1 | 8.756E-005 | 14.81 | 0.0016 |
| A2 2.176E-005 | 1 | 2.176E-005 | 3.68 | 0.0742 |
| B2 6.211E-006 | 1 | 6.211E-006 | 1.05 | 0.3216 |
| C2 7.951E-006 | 1 | 7.951E-006 | 1.25 | 0.2643 |
| D2 9.382E-007 | 1 | 9.382E-007 | 0.16 | 0.6959 |
| AB 2.093E-005 | 1 | 2.093E-005 | 3.54 | 0.0794 |
| AC 2.328E-005 | 1 | 2.328E-005 | 3.94 | 0.0658 |
| AD 6.631E-006 | 1 | 6.631E-006 | 1.12 | 0.3063 |
| BC 1.702E-005 | 1 | 1.702E-005 | 2.88 | 0.1104 |
| BD 1.743E-005 | 1 | 1.743E-005 | 2.95 | 0.1065 |
| CD 3.062E-008 | 1 | 3.062E-008 | 5.181E-003 | 0.9436 |
| Residual 8.866E-005 | 15 | 5.911E-006 |          |          |
| Total 3.656E-004 | 29 |          |          |          |

| **COD**  | Source Squares DF | Square Value | Prob > F |          |
| Model 4.122E+005 | 10 | 41224.29 | 8.63 | < 0.0001 |
| A 242.00 | 1 | 242.00 | 0.051 | 0.8243 |
| B 910.22 | 1 | 910.22 | 0.19 | 0.6673 |
| C 93168.06 | 1 | 93168.06 | 19.51 | 0.0003 |
| D 1.632E+005 | 1 | 1.632E+005 | 34.18 | < 0.0001 |
| AB 1806.25 | 1 | 1806.25 | 0.38 | 0.5458 |
| AC 1122.25 | 1 | 1122.25 | 0.24 | 0.6334 |
| AD 3025.00 | 1 | 3025.00 | 0.63 | 0.4359 |
| BC 5550.25 | 1 | 5550.25 | 1.16 | 0.2945 |
| BD 324.00 | 1 | 324.00 | 0.068 | 0.7973 |
| CD 1.429E+005 | 1 | 1.429E+005 | 29.92 | < 0.0001 |
| Residual 90734.05 | 19 | 4775.48 |          |          |
| Total 5.030E+005 | 29 |          |          |          |

| **Color** | Source Squares DF | Square Value | Prob > F |          |
| Model 86161.10 | 10 | 86161.11 | 3.94 | 0.0050 |
| A 10.89 | 1 | 10.89 | 4.979E-003 | 0.9445 |
| B 22826.72 | 1 | 22826.72 | 10.44 | 0.0044 |
| C 14056.06 | 1 | 14056.06 | 6.43 | 0.0202 |
| D 6536.06 | 1 | 6536.06 | 2.99 | 0.1001 |
| AB 10.56 | 1 | 10.56 | 4.830E-003 | 0.9453 |
| AC 264.06 | 1 | 264.06 | 0.12 | 0.7320 |
| AD 13053.06 | 1 | 13053.06 | 5.97 | 0.0245 |
| BC 21978.06 | 1 | 21978.06 | 10.05 | 0.0050 |
| BD 6930.56 | 1 | 6930.56 | 3.17 | 0.0910 |
| CD 495.06 | 1 | 495.06 | 0.23 | 0.6396 |
| Residual 41548.77 | 19 | 2186.78 |          |          |
| Total 1.277E+005 | 29 |          |          |          |

| **NH3-N** | Source Squares DF | Square Value | Prob > F |          |
| Model 42867.16 | 4 | 10716.79 | 1.92 | 0.1383 |
| A 4864.27 | 1 | 4864.27 | 0.87 | 0.3595 |
| B 7352.80 | 1 | 7352.80 | 1.32 | 0.2619 |
| C 13820.09 | 1 | 13820.09 | 2.48 | 0.1282 |
| D 16830.01 | 1 | 16830.01 | 3.02 | 0.0948 |
| Residual 1.395E+005 | 25 | 5581.53 |          |          |
| Total 1.824E+005 | 29 |          |          |          |
Table 4
Analysis of variance for heavy metals removal.

| Source   | Sum of Mean F | Source Squares | DF | Square Value | Prob | > F |
|----------|---------------|----------------|----|--------------|------|-----|
| Fe⁺²     | Model 11.08   | 14 0.79        | 13.73 < 0.0001 |
|          | A 2.568E-003 | 1 2.568E-003  | 0.045 0.8356 |
|          | B 1.502E-004 | 1 1.502E-004  | 2.607E-003 0.9600 |
|          | C 1.043E-003 | 1 1.043E-003  | 0.018 0.8948 |
|          | D 0.083      | 1 0.083       | 1.44 0.2492 |
|          | A2 2.568E-003| 1 2.568E-003  | 0.045 0.8356 |
|          | B2 1.502E-004| 1 1.502E-004  | 2.607E-003 0.9600 |
|          | C2 1.043E-003| 1 1.043E-003  | 0.018 0.8948 |
|          | D2 0.083     | 1 0.083       | 1.44 0.2492 |
|          | AB 4.622E-004| 1 4.622E-004  | 8.022E-003 0.9298 |
|          | AC 2.560E-004| 1 2.560E-004  | 4.443E-003 0.9477 |
|          | AD 1.822E-004| 1 1.822E-004  | 3.163E-003 0.9559 |
|          | BC 1.822E-004| 1 1.822E-004  | 3.163E-003 0.9559 |
|          | BD 3.610E-004| 1 3.610E-004  | 6.265E-003 0.9380 |
|          | CD 8.930E-003| 1 8.930E-003  | 0.15 0.6994 |
|          | Residual 0.86| 15 0.058      | Total 11.94 29 |
| Pb       | Model 0.26    | 14 0.019      | 3.33 0.0136 |
|          | A 1.834E-003 | 1 1.834E-003  | 0.33 0.5759 |
|          | B 9.145E-004 | 1 9.145E-004  | 0.16 0.6921 |
|          | C 1.920E-003 | 1 1.920E-003  | 0.34 0.5672 |
|          | D 0.12       | 1 0.12       | 21.28 0.0 0.03 |
|          | A2 7.063E-003| 1 7.063E-003  | 0.33 0.5759 |
|          | B2 9.145E-004| 1 9.145E-004  | 0.16 0.6921 |
|          | C2 1.920E-003| 1 1.920E-003  | 0.34 0.5672 |
|          | D2 0.12      | 1 0.12      | 21.28 0.0 0.03 |
|          | AB 1.071E-003| 1 1.071E-003  | 0.19 0.6684 |
|          | AC 6.722E-004| 1 6.722E-004  | 0.18 0.6787 |
|          | AD 2.609E-003| 1 2.609E-003  | 0.47 0.5057 |
|          | BC 8.556E-007| 1 8.556E-007  | 1.525E-004 0.9903 |
|          | BD 3.218E-003| 1 3.218E-003  | 0.57 0.4606 |
|          | CD 3.218E-003| 1 3.218E-003  | 0.57 0.4606 |
|          | Residual 0.084| 15 0.058      | Total 0.35 29 |

(continued on next page)
Table 4 (continued)

| Cu | Sum of Mean F Source Squares DF Square Value Prob > F |
|----|----------------------------------------------------|
| A 2.067E-006 1 2.067E-006 0.24 0.6332 |
| B 6.820E-006 1 6.820E-006 0.78 0.3902 |
| C 5.000E-007 1 5.000E-007 0.057 0.8139 |
| D 1.275E-006 1 1.275E-006 0.15 0.7074 |
| A2 2.026E-005 1 2.026E-005 2.33 0.1480 |
| B2 1.525E-005 1 1.525E-005 1.75 0.2055 |
| C2 4.802E-004 1 4.802E-004 0.5513 < 0.0001 |
| D2 6.702E-007 1 6.702E-007 0.077 0.7853 |
| AB 1.056E-005 1 1.056E-005 1.21 0.2881 |
| AC 5.062E-006 1 5.062E-006 0.58 0.4576 |
| AD 6.250E-008 1 6.250E-008 7.176E-003 0.9336 |
| BC 1.563E-006 1 1.563E-006 0.18 0.6779 |
| BD 6.250E-008 1 6.250E-008 7.176E-003 0.9336 |
| CD 4.556E-005 1 4.556E-005 5.23 0.0371 |
| Residual 1.306E-004 15 8.710E-006 |
| Total 1.015E-003 29 |

| Zn | Sum of Mean F Source Squares DF Square Value Prob > F |
|----|----------------------------------------------------|
| 1.50 14 0.11 4.84 0.0022 |
| A 6.384E-003 1 6.384E-003 0.29 0.5993 |
| B 4.560E-003 1 4.560E-003 0.21 0.6566 |
| C 0.053 1 0.053 2.40 0.1425 |
| D 0.15 1 0.15 6.65 0.0210 |
| A2 0.053 1 0.053 2.39 0.1433 |
| B2 0.017 1 0.017 0.75 0.4010 |
| C2 0.30 1 0.30 13.67 0.0021 |
| D2 0.029 1 0.029 1.29 0.2734 |
| AB 2.265E-004 1 2.265E-004 0.010 0.9208 |
| AC 1.321E-003 1 1.321E-003 0.060 0.8104 |
| AD 1.201E-003 1 1.201E-003 0.054 0.8191 |
| BC 0.058 1 0.058 2.60 0.1278 |
| BD 0.081 1 0.081 3.64 0.0759 |
| CD 0.071 1 0.071 3.21 0.0934 |
| Residual 0.33 15 0.022 |
| Total 1.83 29 |

Table 5
Equations of coded factors for TSS, COD, Color and ammonia removal.

\[ \text{TSS} = 1.501E-003 + 1.050E-003 A + 1.344E-003 B + 1.556E-004 C - 2.206E-003 D + 2.898E-003 A2 + 1.548E-003 B2 - 1.752E-003 C2 - 6.018E-004 D2 + 1.144E-003 AB - 1.206E-003 AC - 6.437E-004 AD - 1.031E-003 BC - 1.044E-003 BD - 4.375E-005 CD (3) \]

\[ \text{COD} = + 268.63 - 3.67 A - 7.11 B - 71.94 C - 95.22 D - 10.63 AB - 8.38 AC + 13.75 A D + 18.62 BC - 4.50 BD + 94.50 CD (4) \]

\[ \text{Color} = + 71.73 + 0.78 A - 35.61 B - 27.94 C - 19.06 D + 0.81 AB + 4.06 AC + 28.36 AD + 37.06 B C + 20.81 BD + 5.56 CD (5) \]

\[ \text{Ammonia} = + 58.91 + 16.44 A + 20.21 B + 27.71 C + 30.58 D (6) \]

2.2. Coagulation process by using ZnSO₄

2.2.1. Preparation of reagent

In this section rubber wastewater was coagulated using Zinc sulphate (ZnSO₄). A set of ZnSO₄ dosages were added to rubber wastewater samples gradually to determine the optimum conditions. The performance of the best dosage was selected based on COD, Color and NH₃–N removal efficiencies. Orbital Shaker (Luckham R100/TW Rotatable Shaker 340 mm X 245 mm) with at 200 rpm was used for samples shaking [5]. All experiments were performed at room tempera-
ture (28 °C) using 100 mL of rubber wastewater samples placed in conical flasks with a 250 mL capacity. pH of the samples was controlled by using 3 M of sulphuric acid solution and sodium hydroxide solution, respectively [6]. All experiments were performed at laboratory of Malaysian Institute of chemical & Bioengineering Technology, University of Kuala Lumpur, Melaka, Malaysia.

2.3. Experimental design

Four factors, namely ZnSO₄ dosage (A), pH (B), reaction time (C) and mixing ratio (D) are thought to be influential factors on nine responses TSS, COD, color, ammonia, Fe, K, Pb, Cu, and Zn, removal efficiency from rubber wastewater samples was tested and evaluated. Face centered composite design (FCCD) in response surface methodology (RSM) was used to investigate the effect of the four factors on the selected responses and find the optimum operating conditions for the four factors. The levels of selected factors were chosen based on literature and preliminary experiments, the actual and coded levels are given in Table 2.

The relationship between the selected factors (A, B, C, D) and each of the responses is usually described in response surface methodology (RSM) by a second-order polynomial as given in

![Fig. 1. Response surface curves for the effect of two factor interaction on a)TSS, B) COD, C) Color and D) Ammonia.](image)
Fig. 2. Response surface curves for the effect of two factor on a) Fe, B) K, C) Pb, D) Cu and E) Zn.

Eq. (1).

\[ Y = \beta_0 + \sum_{i=1}^{4} \beta_i X_i + \sum_{i}^{4} \beta_{ii} X_i^2 + \sum_{i<j} \beta_{ij} X_{ij} \]
Fig. 3. Interaction curves showing the behavior of two factors on the effect of a) TSS, b) COD, c) Color and d) Ammonia.

### Table 6
Equations of coded factors for heavy metals removal.

| Metal | Equation                                                                 |
|-------|--------------------------------------------------------------------------|
| Fe    | $y = +1.19 +0.012 A +2.889E-003 B -7.611E-003 C +0.068 D +0.24 A2 +0.22 B2 1.16 C2 -0.51 D2 -5.375E-003 AB +4.000E-003 AC +3.375E-003 A D -3.375E-003 BC -4.750E-003 x B x D -0.024 x C x D (7) |
| K     | $y = +1.04 -0.010 A +7.128E-003 B -0.010 C +0.081 x D +0.052 A2 +0.14 B2 -0.21 C2 +0.022 D2 +8.181E-003 A B +0.012 AC -3.206E-003 AD +0.013 BC +2.313E-004 BD +0.014 CD (8) |
| Pb    | $y = +0.22 +8.039E-003 A -0.012 B -6.111E-003 C +8.428E-003 D +0.014 A2 +0.014 B2 -0.18 C2 -0.047 D2 -2.813E-003 AB -1.063E-003 AC -9.562E-003 AD -2.312E-003 BC -0.010 BD -0.025 CD (9) |
| Cu    | $y = +0.011 -3.389E-004 A -6.156E-004 B +1.667E-004 C -2.661E-004 D +2.796E-003 A2 +2.426E-003 B2 -0.014 C2 +5.086E-004 D2 +8.125E-004 AB +5.625E-004 AC -6.250E-005 AD +3.125E-004 BC -6.250E-005 BD +1.688E-003 CD (10) |
| Zn    | $y = +0.64 +0.019 A -0.016 B +0.054 C +0.090 D +0.14 A2 -0.080 B2-0.34 C2 -0.11 x D2 +3.763E-003 AB +9.088E-003 AC -8.662E-003 AD +0.060 BC +0.071 BD +0.067 CD (11) |
where $Y$ represents the dependent variable ($TSS$, $COD$, $color$, $ammonia$, $Fe$, $K$, $Pb$, $Cu$, $Zn$), $\beta_0$, $\beta_i$ and $\beta_{ij}$ are linear coefficient, quadratic coefficient and interaction coefficients respectively, need to be estimated, and $X_i$ represents the independent variables ($A$, $B$, $C$, $D$).

All possible combination of selected factors ($A$, $B$, $C$, and $D$) to run FCCD is represented by thirty experiments distributed as follows: sixteen experiments for the factorial design, eight experiments are for axial (star) points and six experiments at the center of the design [2]. To avoid
or minimize the effect of unexpected variability in the responses, the experiments were run in random order.

2.4. Analytical methods

COD, color and NH$_3$–N, were immediately tested before and after each experiment using UV-VIS spectrophotometer (HACH DR 2800). Leachate sample was shacked well analyzed. NH$_3$–N concentration was measured by the Phenol Method No. (4500) using a UV-VIS spectrophotometer at 640 nm with a light path of 1 cm or greater. pH was measured using a portable digital pH/Mv meter (Inolab pH 720, WTW 82362 Weilheim, Germany). COD concentration was determined by the open reflux method No. (5220). Heavy metals were tested by Atomic Absorption Spectroscopy (UNICAM 929 AA spectrometer). The test values are presented as the average of the three measurements, and the difference between the measurements of each value was less than 3%. The removal efficiencies of COD and NH$_3$–N were obtained using the following Eq. (2):

$$\text{Removal(\%)} = \left[ \frac{(C_i - C_f)}{C_i} \right] \times 100$$

where $C_i$ and $C_f$ refer to the initial and final TSS, COD, Color and NH$_3$–N concentrations, respectively.

CRediT Author Statement

Abbas F.M. Alkarkhi: Writing, original draft preparation, Conceptualization, supervision; Salem S. Abu Amr: Writing, Data curation, Conceptualization, Methodology; Wasin A.A. Alqaraghuli: Writing, data curation, modeling; Yahya Özdemir: software, reviewing, editing; Muazafar Zulkifli: Writing, visualization, methodology; M.N. Mahmud: reviewing, editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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