

# **Central Composite Design Optimization of Banana Peels/Magnetite for Anaerobic Biogas Production from Wastewater**

**Jeremiah A. Adedeji \*, Emmanuel Kweinor Tetteh, Gloria Amo-Duodu, Edward Kwaku Armah, Sudesh Rathilal and Maggie Chetty**

Green Engineering and Sustainability Research Group; Department of Chemical Engineering,  
Faculty of Engineering and The Built Environment, Durban University of Technology,  
Durban 4001, South Africa

\* Correspondence: [jerry\\_4real@live.com](mailto:jerry_4real@live.com)

Table S1: Central composite design optimised conditions.

| Number   | Nano         | Biochar<br>loading rate | pH           | Biogas<br>production | COD<br>reduction | Desirability          |
|----------|--------------|-------------------------|--------------|----------------------|------------------|-----------------------|
| <b>1</b> | <b>0.461</b> | <b>0.666</b>            | <b>7.071</b> | <b>19.260</b>        | <b>75.172</b>    | <b>1.000 Selected</b> |
| 2        | 0.400        | 1.500                   | 7.043        | 11.830               | 69.505           | 1.000                 |
| 3        | 0.600        | 1.000                   | 7.173        | 23.513               | 69.635           | 1.000                 |
| 4        | 0.400        | 1.000                   | 7.015        | 23.891               | 70.930           | 1.000                 |
| 5        | 0.400        | 0.500                   | 7.063        | 11.419               | 78.405           | 1.000                 |
| 6        | 0.200        | 1.000                   | 6.872        | 18.401               | 68.375           | 1.000                 |
| 7        | 0.600        | 1.500                   | 7.237        | 9.067                | 68.700           | 1.000                 |
| 8        | 0.200        | 1.500                   | 7.218        | 8.726                | 66.460           | 1.000                 |
| 9        | 0.600        | 0.500                   | 6.997        | 13.428               | 76.620           | 1.000                 |
| 10       | 0.257        | 0.502                   | 6.900        | 6.504                | 77.267           | 1.000                 |
| 11       | 0.201        | 1.476                   | 7.193        | 9.789                | 66.450           | 1.000                 |
| 12       | 0.301        | 0.901                   | 6.934        | 21.140               | 71.186           | 1.000                 |
| 13       | 0.332        | 1.331                   | 7.013        | 17.969               | 68.764           | 1.000                 |
| 14       | 0.206        | 1.394                   | 7.116        | 13.009               | 66.508           | 1.000                 |
| 15       | 0.419        | 1.411                   | 7.038        | 15.787               | 69.397           | 1.000                 |
| 16       | 0.348        | 1.090                   | 6.981        | 22.784               | 69.912           | 1.000                 |
| 17       | 0.411        | 0.943                   | 7.025        | 23.856               | 71.508           | 1.000                 |
| 18       | 0.350        | 1.142                   | 6.987        | 22.304               | 69.596           | 1.000                 |
| 19       | 0.219        | 1.330                   | 7.056        | 15.394               | 66.880           | 1.000                 |
| 20       | 0.229        | 1.019                   | 6.898        | 19.623               | 68.802           | 1.000                 |
| 21       | 0.416        | 0.616                   | 7.055        | 16.828               | 76.142           | 1.000                 |
| 22       | 0.337        | 1.055                   | 6.972        | 22.751               | 70.072           | 1.000                 |
| 23       | 0.580        | 1.199                   | 7.185        | 21.093               | 68.823           | 1.000                 |
| 24       | 0.429        | 1.421                   | 7.043        | 15.395               | 69.439           | 1.000                 |
| 25       | 0.489        | 1.006                   | 7.083        | 24.435               | 70.779           | 1.000                 |
| 26       | 0.274        | 1.211                   | 6.979        | 19.641               | 68.293           | 1.000                 |
| 27       | 0.554        | 0.716                   | 7.091        | 21.083               | 73.563           | 1.000                 |
| 28       | 0.566        | 1.105                   | 7.158        | 23.074               | 69.409           | 1.000                 |
| 29       | 0.438        | 0.649                   | 7.063        | 18.398               | 75.532           | 1.000                 |
| 30       | 0.219        | 0.533                   | 6.824        | 6.236                | 75.991           | 1.000                 |
| 31       | 0.305        | 0.892                   | 6.938        | 21.144               | 71.344           | 1.000                 |
| 32       | 0.425        | 0.697                   | 7.051        | 19.723               | 74.744           | 1.000                 |
| 33       | 0.465        | 0.552                   | 7.076        | 15.064               | 77.209           | 1.000                 |
| 34       | 0.491        | 1.332                   | 7.086        | 18.453               | 69.344           | 1.000                 |
| 35       | 0.591        | 0.691                   | 7.080        | 20.247               | 73.398           | 1.000                 |

|    |       |       |       |        |        |       |
|----|-------|-------|-------|--------|--------|-------|
| 36 | 0.346 | 0.786 | 6.980 | 20.378 | 73.145 | 1.000 |
| 37 | 0.391 | 0.605 | 7.040 | 15.881 | 76.313 | 1.000 |
| 38 | 0.462 | 0.629 | 7.073 | 18.051 | 75.792 | 1.000 |
| 39 | 0.469 | 0.836 | 7.070 | 23.310 | 72.644 | 1.000 |
| 40 | 0.495 | 1.041 | 7.088 | 24.283 | 70.469 | 1.000 |
| 41 | 0.389 | 0.850 | 7.013 | 22.544 | 72.500 | 1.000 |
| 42 | 0.474 | 1.184 | 7.071 | 22.520 | 69.737 | 1.000 |
| 43 | 0.337 | 0.979 | 6.968 | 22.737 | 70.746 | 1.000 |
| 44 | 0.387 | 1.449 | 7.035 | 14.165 | 69.294 | 1.000 |
| 45 | 0.580 | 0.881 | 7.132 | 23.587 | 71.059 | 1.000 |
| 46 | 0.227 | 0.646 | 6.834 | 11.726 | 73.924 | 1.000 |
| 47 | 0.591 | 0.555 | 7.030 | 15.773 | 75.726 | 1.000 |
| 48 | 0.497 | 1.056 | 7.091 | 24.176 | 70.345 | 1.000 |
| 49 | 0.438 | 1.051 | 7.043 | 24.121 | 70.571 | 1.000 |
| 50 | 0.280 | 1.440 | 7.072 | 13.240 | 68.023 | 1.000 |
| 51 | 0.543 | 0.511 | 7.053 | 13.971 | 77.294 | 1.000 |
| 52 | 0.291 | 1.266 | 6.997 | 18.958 | 68.363 | 1.000 |
| 53 | 0.270 | 0.836 | 6.900 | 19.112 | 71.602 | 1.000 |
| 54 | 0.307 | 0.617 | 6.955 | 13.876 | 75.569 | 1.000 |
| 55 | 0.323 | 0.911 | 6.954 | 21.872 | 71.327 | 1.000 |
| 56 | 0.336 | 1.290 | 7.004 | 19.207 | 68.879 | 1.000 |
| 57 | 0.591 | 1.315 | 7.212 | 17.476 | 68.467 | 1.000 |
| 58 | 0.207 | 1.254 | 7.012 | 16.805 | 66.809 | 1.000 |
| 59 | 0.297 | 0.950 | 6.935 | 21.537 | 70.596 | 1.000 |
| 60 | 0.492 | 1.324 | 7.088 | 18.701 | 69.343 | 1.000 |
| 61 | 0.424 | 1.426 | 7.041 | 15.200 | 69.433 | 1.000 |
| 62 | 0.426 | 1.134 | 7.033 | 23.269 | 70.023 | 1.000 |
| 63 | 0.299 | 0.701 | 6.936 | 16.600 | 74.015 | 1.000 |
| 64 | 0.587 | 1.491 | 7.214 | 9.886  | 68.828 | 1.000 |
| 65 | 0.208 | 0.896 | 6.842 | 17.680 | 69.707 | 1.000 |
| 66 | 0.257 | 1.070 | 6.930 | 20.597 | 68.888 | 1.000 |
| 67 | 0.492 | 0.844 | 7.083 | 23.526 | 72.429 | 1.000 |
| 68 | 0.291 | 0.773 | 6.922 | 18.401 | 72.787 | 1.000 |
| 69 | 0.239 | 0.866 | 6.869 | 18.485 | 70.688 | 1.000 |
| 70 | 0.487 | 0.857 | 7.081 | 23.687 | 72.294 | 1.000 |
| 71 | 0.480 | 0.528 | 7.077 | 14.237 | 77.578 | 1.000 |
| 72 | 0.387 | 1.018 | 7.005 | 23.715 | 70.726 | 1.000 |
| 73 | 0.358 | 1.399 | 7.026 | 15.987 | 69.004 | 1.000 |
| 74 | 0.237 | 0.873 | 6.867 | 18.506 | 70.566 | 1.000 |
| 75 | 0.545 | 0.849 | 7.110 | 23.542 | 71.891 | 1.000 |
| 76 | 0.302 | 1.193 | 6.977 | 20.639 | 68.803 | 1.000 |

|     |              |              |       |        |        |       |
|-----|--------------|--------------|-------|--------|--------|-------|
| 77  | <i>0.534</i> | <i>1.248</i> | 7.132 | 20.581 | 69.186 | 1.000 |
| 78  | <i>0.279</i> | <i>0.653</i> | 6.914 | 14.218 | 74.602 | 1.000 |
| 79  | <i>0.573</i> | <i>0.948</i> | 7.141 | 23.968 | 70.491 | 1.000 |
| 80  | <i>0.347</i> | <i>0.943</i> | 6.975 | 22.747 | 71.188 | 1.000 |
| 81  | <i>0.442</i> | <i>0.987</i> | 7.047 | 24.298 | 71.094 | 1.000 |
| 82  | <i>0.566</i> | <i>0.898</i> | 7.128 | 23.838 | 71.077 | 1.000 |
| 83  | <i>0.551</i> | <i>1.234</i> | 7.151 | 20.710 | 69.062 | 1.000 |
| 84  | <i>0.456</i> | <i>0.986</i> | 7.058 | 24.380 | 71.082 | 1.000 |
| 85  | <i>0.202</i> | <i>1.130</i> | 6.938 | 18.331 | 67.346 | 1.000 |
| 86  | <i>0.592</i> | <i>0.823</i> | 7.121 | 22.839 | 71.560 | 1.000 |
| 87  | <i>0.586</i> | <i>0.851</i> | 7.127 | 23.239 | 71.313 | 1.000 |
| 88  | <i>0.550</i> | <i>1.058</i> | 7.137 | 23.815 | 69.892 | 1.000 |
| 89  | <i>0.363</i> | <i>0.887</i> | 6.989 | 22.534 | 71.928 | 1.000 |
| 90  | <i>0.277</i> | <i>0.658</i> | 6.910 | 14.322 | 74.470 | 1.000 |
| 91  | <i>0.306</i> | <i>0.941</i> | 6.941 | 21.720 | 70.811 | 1.000 |
| 92  | <i>0.514</i> | <i>0.875</i> | 7.097 | 23.917 | 71.899 | 1.000 |
| 93  | <i>0.334</i> | <i>1.152</i> | 6.980 | 21.898 | 69.391 | 1.000 |
| 94  | <i>0.565</i> | <i>0.786</i> | 7.106 | 22.516 | 72.424 | 1.000 |
| 95  | <i>0.233</i> | <i>0.540</i> | 6.850 | 7.284  | 76.087 | 1.000 |
| 96  | <i>0.230</i> | <i>1.164</i> | 6.958 | 19.009 | 67.732 | 1.000 |
| 97  | <i>0.410</i> | <i>1.394</i> | 7.033 | 16.458 | 69.347 | 1.000 |
| 98  | <i>0.305</i> | <i>0.912</i> | 6.939 | 21.415 | 71.113 | 1.000 |
| 99  | <i>0.436</i> | <i>1.224</i> | 7.041 | 21.685 | 69.633 | 1.000 |
| 100 | <i>0.299</i> | <i>1.136</i> | 6.964 | 21.321 | 69.063 | 1.000 |