**Supplementary files**

**Temporal variation in Leachate composition of a newly constructed Landfill Site in Lahore in context to human and environmental risks**

Mahsoon Ashraf1, Muhammad Zeshan1, Sadia Hafeez1, Rahib Hussain1\*, Abdul Qadir1\*, Muzaffar Majid1, Farman Ahmad2, Sajid Rashid Ahmad1

1*College of Earth and Environmental Sciences, University of the Punjab, Lahore 54590, Pakistan*

2*School of Food and Nutrition, Minhaj University Lahore, Lahore 54770, Pakatan*

*Author for correspondence:*  [aqadir.cees@pu.edu.pk](mailto:aqadir.cees@pu.edu.pk)/ [rahibpcr@gmail.com](mailto:rahibpcr@gmail.com)

**Table S1** Determination of Physiochemical parameters in the Leachates collected from newly constructed landfill (Lakhodair landfill), Lahore

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Unit** | **NEQS** | **Feb.17** | **Mar.17** | **Apr.17** | **May.17** | **Jun.17** | **July.17** | **Aug.17** | **Sep.17** | **Oct. 17** | **Nov. 17** | **Dec. 17** | **Jan. 18** |
| **PH** |  | **9** | 8.87 | 8.65 | 8.95 | 8.27 | 9.02 | 9.14 | 8.64 | 9.05 | 8.68 | 8.8 | 9.18 | 8.61 |
| **TDS** | mg/L | **3500** | 17000 | 18040 | 19180 | 25640 | 19320 | 17900 | 18800 | 18360 | 24136 | 19708 | 6736 | 17580 |
| **TSS** | mg/L | **400** | 520 | 120 | 240 | 920 | 220 | 300 | 280 | 280 | 572 | 60 | 540 | 224 |
| **Oil & Grease** | mg/L | **10** | 20 | 40 | 20 | 20 | 20 | 40 | 20 | 3 | 40 | 11 | 26 | 6 |
| **COD** | mg/L | **400** | 5716 | 6273 | 5563 | 12620 | 6060 | 5823 | 5833 | 5516 | 12240 | 7520 | 4553 | 8590 |
| **NH3, Nitrogen** | mg/L | **40** | 1250 | 625 | 480 | 420 | 430 | 900 | 374 | 288 | 322 | 482 | 471 | 490 |
| **(BOD5) @ 20 °C** | mg/L | **250** | 2850 | 240 | 1112 | 4200 | 620 | 1208 | 325 | 548 | 1110 | 408 | 1980 | 2700 |
| **Sulfate** | mg/L | **1000** | 102 | 1150 | 360 | 49 | 16 | 1100 | 170 | 700 | 280 | 10400 | 47 | 740 |
| **Sulfides** |  | **1** | 21 | 9.25 | 0.87 | 3.61 | 2.1 | 1.7 | 0.32 | 2.05 | 12.24 | 2.83 | 10.8 | 0.98 |
| **Chloride** | mg/L | **1000** | 4098 | 7148 | 4098 | 8097 | 4774 | 4324 | 4099 | 4648 | 5748 | 350 | 1699 | 4998 |
| **Fluoride** | mg/L | **10** | 3.6 | 3.8 | 1.29 | 0.2 | 3.5 | 4.2 | 0.21 | 0.25 | 1.35 | 0.39 | 1.57 | 2.18 |
| **Ionic Detergents** | mg/L | **20** | 0.019 | 15.48 | 3.486 | 5.486 | 5.467 | 0.011 | 0.014 | 0.024 | 0.009 | 0.7 | 0.81 | 4.8 |
| **Arsenic (As)** | mg/L | **1** | 0 | 0.01 | 0 | 0 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0.025 |
| **Cadmium (Cd)** | mg/L | **0.1** | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.04 | 0.06 | 0.15 | 0.15 | 0.08 | 0 | 0 |
| **Chromium (Cr)** | mg/L | **1** | 0.04 | 0.05 | 0.03 | 0.1 | 0.06 | 0.03 | 0.05 | 0.09 | 0.11 | 0.51 | 0.05 | 0.03 |
| **Copper (Cu)** | mg/L | **1** | 0.15 | 0.81 | 0.09 | 0.2 | 0.12 | 0.27 | 0.07 | 0.15 | 0.3 | 0.1 | 0.07 | 0.29 |
| **Iron (Fe)** | mg/L | **8** | 6.65 | 14.1 | 3.35 | 0.4 | 6.5 | 8.9 | 3.2 | 2.07 | 3.1 | 5.6 | 3.73 | 3.55 |
| **Lead (Pb)** | mg/L | **0.5** | 0.07 | 0.09 | 0.012 | 0.018 | 0.052 | 0.27 | 0.035 | 0.05 | 0.022 | 0.05 | 0.022 | 0.025 |
| **Manganese (Mn)** | mg/L | **1.5** | 0.35 | 1.27 | 1.08 | 1.52 | 1.44 | 1.08 | 0.92 | 0.03 | 11.8 | 0.221 | 0.13 | 0.31 |
| **Nickel (Ni)** | mg/L | **1** | 0.59 | 0.41 | 0.34 | 0.25 | 0.2 | 0.18 | 0.21 | 0.03 | 1.56 | 0.07 | 0 | 0.43 |
| **Zinc (Zn)** | mg/L | **5** | 6.1 | 5.82 | 6.68 | 5.4 | 4.82 | 5.78 | 6.02 | 3.28 | 4.02 | 0.19 | 0.31 | 0.5 |
| **Mercury (Hg)** | mg/L | **0.01** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Silver** | mg/L | **1** | 0.03 | 0.021 | 0.018 | 0.012 | 0.015 | 0.013 | 0.015 | 0.021 | 0.031 | 0.022 | 0 | 0 |
| **Barium** | mg/L | **1.5** | 0.15 | 0.134 | 0.119 | 0.16 | 0.13 | 0.128 | 0.134 | 0.127 | 0.019 | 0.103 | 0.049 | 0.057 |
| **Boron** | mg/L | **6** | 5.6 | 6.8 | 5.2 | 1 | 1.2 | 1.1 | 1.4 | 0.9 | 1 | 15.2 | 0 | 1.2 |
| **Cyanide** | mg/L | **1** | 0.008 | 0.007 | 0.008 | 0.076 | 0.072 | 0.968 | 0.455 | 0.234 | 0.07 | 0.062 | 0.04 | 0.032 |
| **Selenium** | mg/L | **0.5** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phenolic compound** | mg/L | **0.3** | 0.231 | 0.158 | 0.138 | 0.22 | 0.224 | 0.231 | 0.418 | 0.346 | 0.412 | 0.316 | 0.8 | 0.46 |
| **Total Toxic Metals** | mg/L | **2** | 1.24 | 1.2 | 1.629 | 2.1 | 1.98 | 1.55 | 1.42 | 0.498 | 13.29 | 1.06 | 0.251 | 0.877 |
| **Total Chlorine** | mg/L | **1** | 0.25 | 0.11 | 0.04 | 0.07 | 0.09 | 0.05 | 0.06 | 0.06 | 0.03 | 0.09 | 0.08 | 0.13 |
| **COD/ NH3-N** |  |  | 4.5728 | 10.0368 | 11.5895 | 30.0479 | 14.092 | 6.47 | 15.596 | 19.1527 | 38.0124 | 15.601 | 9.6667 | 17.531 |
| **BOD/COD** |  |  | 0.4986 | 0.03259 | 0.19989 | 0.3328 | 0.1023 | 0.2074 | 0.0557 | 0.09937 | 0.09863 | 0.0545 | 0.4348 | 0.3149 |

**Table S2** Determination of coefficient concentration for leachates in Lakhodair landfill site and their associated health risk.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Specification** | **spring** | | |  | **summer** | | | |  | **autumn** | |  | **winter** | | |
| **Parameters** | **Feb.17** | **Mar.17** | **Apr.17** |  | **May.17** | **Jun.17** | **July.17** | **Aug.17** |  | **Sep.17** | **Oct. 17** |  | **Nov. 17** | **Dec. 17** | **Jan. 18** |
| **TDS** | 4.85714 | 5.15428 | 5.48 |  | 7.3257 | 5.52 | 5.11428 | 5.371286 |  | 5.2457 | 6.896 |  | 5.6308 | 1.92457 | 5.02285 |
| **TSS** | 1.3 | 0.3 | 0.6 |  | 2.3 | 0.55 | 0.75 | 0.7 |  | 0.7 | 1.43 |  | 0.15 | 1.35 | 0.56 |
| **Oil & Grease** | 2 | 4 | 2 |  | 2 | 2 | 4 | 2 |  | 0.3 | 4 |  | 1.1 | 2.6 | 0.6 |
| **COD** | 14.29 | 15.6825 | 13.9075 |  | 31.55 | 15.15 | 14.5575 | 14.5825 |  | 13.79 | 30.6 |  | 18.8 | 11.3825 | 21.475 |
| **NH3, Nitrogen** | 31.25 | 15.625 | 12 |  | 10.5 | 10.75 | 22.5 | 9.35 |  | 7.2 | 8.05 |  | 12.05 | 11.775 | 12.25 |
| **BOD5 @ 20 °C** | 11.4 | 0.96 | 4.448 |  | 16.8 | 2.48 | 4.832 | 1.3 |  | 2.192 | 4.44 |  | 1.632 | 7.92 | 10.8 |
| **Sulfate** | 0.102 | 1.15 | 0.36 |  | 0.049 | 0.016 | 1.1 | 0.17 |  | 0.7 | 0.28 |  | 10.4 | 0.047 | 0.74 |
| **Sulfides** | 21 | 9.25 | 0.87 |  | 3.61 | 2.1 | 1.7 | 0.32 |  | 2.05 | 12.24 |  | 2.83 | 10.8 | 0.98 |
| **Chloride** | 4.098 | 7.148 | 4.098 |  | 8.097 | 4.774 | 4.324 | 4.099 |  | 4.648 | 5.748 |  | 0.35 | 1.699 | 4.998 |
| **Fluoride** | 0.36 | 0.38 | 0.129 |  | 0.02 | 0.35 | 0.42 | 0.021 |  | 0.025 | 0.135 |  | 0.039 | 0.157 | 0.218 |
| **Ionic Detergents** | 0.00095 | 0.774 | 0.1743 |  | 0.2743 | 0.27335 | 0.00055 | 0.0007 |  | 0.0012 | 0.00045 |  | 0.035 | 0.0405 | 0.24 |
| **Arsenic (As)** | 0 | 0.01 | 0 |  | 0 | 0.05 | 0.05 | 0 |  | 0 | 0 |  | 0 | 0 | 0.025 |
| **Cadmium (Cd)** | 0.1 | 0.2 | 0.3 |  | 0.4 | 0.5 | 0.4 | 0.6 |  | 1.5 | 1.5 |  | 0.8 | 0 | 0 |
| **Chromium (Cr)** | 0.04 | 0.05 | 0.03 |  | 0.1 | 0.06 | 0.03 | 0.05 |  | 0.09 | 0.11 |  | 0.51 | 0.05 | 0.03 |
| **Copper (Cu)** | 0.15 | 0.81 | 0.09 |  | 0.2 | 0.12 | 0.27 | 0.07 |  | 0.15 | 0.3 |  | 0.1 | 0.07 | 0.29 |
| **Iron (Fe)** | 0.83125 | 1.7625 | 0.41875 |  | 0.05 | 0.8125 | 1.1125 | 0.4 |  | 0.25875 | 0.3875 |  | 0.7 | 0.46625 | 0.4437 |
| **Lead (Pb)** | 0.14 | 0.18 | 0.024 |  | 0.036 | 0.104 | 0.54 | 0.07 |  | 0.1 | 0.044 |  | 0.1 | 0.044 | 0.05 |
| **Manganese (Mn)** | 0.233 | 0.8467 | 0.72 |  | 1.0133 | 0.96 | 0.72 | 0.6133 |  | 0.02 | 7.8667 |  | 0.1473 | 0.0867 | 0.2067 |
| **Nickel (Ni)** | 0.59 | 0.41 | 0.34 |  | 0.25 | 0.2 | 0.18 | 0.21 |  | 0.03 | 1.56 |  | 0.07 | 0 | 0.43 |
| **Zinc (Zn)** | 1.22 | 1.164 | 1.336 |  | 1.08 | 0.964 | 1.156 | 1.204 |  | 0.656 | 0.804 |  | 0.038 | 0.062 | 0.1 |
| **Silver** | 0.03 | 0.021 | 0.018 |  | 0.012 | 0.015 | 0.013 | 0.015 |  | 0.021 | 0.031 |  | 0.022 | 0 | 0 |
| **Barium** | 0.1 | 0.08933 | 0.0793 |  | 0.1067 | 0.08667 | 0.08533 | 0.08933 |  | 0.08467 | 0.0127 |  | 0.0687 | 0.0327 | 0.038 |
| **Boron** | 0.9333 | 1.13333 | 0.8667 |  | 0.1667 | 0.2 | 0.1833 | 0.23333 |  | 0.15 | 0.1667 |  | 2.5333 | 0 | 0.2 |
| **Cyanide** | 0.008 | 0.007 | 0.008 |  | 0.076 | 0.072 | 0.968 | 0.455 |  | 0.234 | 0.07 |  | 0.062 | 0.04 | 0.032 |
| **Phenolic compound** | 0.77 | 0.52667 | 0.46 |  | 0.7333 | 0.74667 | 0.77 | 1.3933 |  | 1.1533 | 1.37333 |  | 1.05333 | 2.6667 | 1.5333 |
| **Total Toxic Metals** | 0.62 | 0.6 | 0.8145 |  | 1.05 | 0.99 | 0.775 | 0.71 |  | 0.249 | 6.645 |  | 0.53 | 0.1255 | 0.4385 |
| **Total Chlorine** | 0.25 | 0.11 | 0.04 |  | 0.07 | 0.09 | 0.05 | 0.06 |  | 0.06 | 0.03 |  | 0.09 | 0.08 | 0.13 |
| Unit – mg/L, 17- 2017, 18- 2018 | | | | | | | | | | |  |  |  |  |  |

**Table S3** Evaluation and interpreted of seasonal Physiochemical data of Lakhodair Leachates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S.N** | **Parameters** | **Spring** | **Summer** | **Autumn** | **Winter** |
| 1 | **PH** | 8.823±0.155 | 8.767±0.394 | 8.865±0.261 | 8.863±0.290 |
| 2 | **TDS** | 18073.3±1090.382 | 20415±3532.379 | 21248±4084.249 | 14674.67±6956.933 |
| 3 | **TSS** | 293.333±205.264 | 430±328.430 | 426±206.475 | 274.67±243.978 |
| 4 | **Oil & Grease** | 26.67±11.547 | 25±10 | 21.5±26.162 | 14.333±10.408 |
| 5 | **COD** | 5850.67±373.666 | 7584±3359.117 | 8878±4754.586 | 6887.67±2091.465 |
| 6 | **NH­3-Nitrogen** | 785±409.176 | 531±247.205 | 305±24.041 | 481±9.539 |
| 7 | **(BOD5) @ 20 °C** | 1400.67±1328.729 | 1588.25±1779.432 | 829±397.394 | 1696±1172.096 |
| 8 | **Sulfate** | 537.333±546.041 | 333.75±515.105 | 490±296.984 | 3729±5787.637 |
| 9 | **Sulfides** | 10.373±10.111 | 1.932±1.353 | 7.145±7.205 | 4.87±5.218 |
| 10 | **Chloride** | 5114.67±1760.98 | 5323.5±1870.174 | 5198±777.817 | 2349±2391.203 |
| 11 | **Fluoride** | 2.896±1.395 | 2.027±2.123 | 0.8±0.777 | 1.38±0.91 |
| 12 | **Ionic Detergents** | 6.328±8.112 | 2.744±3.154 | 0.016±0.010 | 2.103±2.336 |
| 13 | **Total Chlorine** | 0.133±0.106 | 0.067±0.017 | 0.045±0.021 | 0.1±0.026 |
| 14 | **Phenolic compounds** | 0.175±0.048 | 0.273±0.096 | 0.379±0.046 | 0.525±0.248 |
|  | **Arsenic (As)** | 0.003±0.005 | 0.025±0.028 | 0.000±0 | 0.008±0.014 |
| 2 | **Cadmium (Cd)** | 0.020±0.01 | 0.048±0.009 | 0.150±0 | 0.027±0.046 |
| 3 | **Chromium (Cr)** | 0.040±0.01 | 0.060±0.029 | 0.100±0.014 | 0.197±0.271 |
| 4 | **Copper (Cu)** | 0.350±0.399 | 0.165±0.088 | 0.225±0.106 | 0.153±0.119 |
| 5 | **Iron (Fe)** | 8.033±5.506 | 4.750±3.724 | 2.585±0.728 | 4.293±1.135 |
| 6 | **Lead (Pb)** | 0.057±0.040 | 0.094±0.118 | 0.036±0.019 | 0.032±0.015 |
| 7 | **Manganese (Mn)** | 0.900±0.485 | 1.240±0.286 | 5.915±8.322 | 0.220±0.090 |
| 8 | **Nickel (Ni)** | 0.447±0.128 | 0.210±0.029 | 0.795±1.081 | 0.167±0.230 |
| 9 | **Zinc (Zn)** | 6.200±0.438 | 5.505±0.523 | 3.650±0.523 | 0.333±0.156 |
| 10 | **Silver** | 0.023±0.006 | 0.014±0.001 | 0.026±0.007 | 0.007±0.012 |
| 11 | **Barium** | 0.134±0.015 | 0.138±0.014 | 0.073±0.076 | 0.070±0.029 |
| 12 | **Boron** | 5.867±0.832 | 1.175±0.170 | 0.950±0.070 | 5.467±8.450 |
| 13 | **Cyanide** | 0.008±0.000 | 0.393±0.423 | 0.152±0.115 | 0.045±0.015 |
| 14 | **Total Toxic Metals** | 1.356±0.236 | 1.763±0.328 | 6.894±9.045 | 0.729±0.424 |

**Table S4** Determination of Variance (ANOVA) for Physico-Chemical Parameters of leachates collected from Lakhodair landfill site.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Factors | **ANOVA: Single Factor** | | | | | | |
|  | *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| pH | Between Groups | 37.590475 | 3 | 12.530158 | 0.764628 | 0.535427 | 3.490295 |
| TDS |  | 246686648 | 3 | 82228883 | 0.975759 | 0.436344 | 3.490295 |
| TSS |  | 141659 | 3 | 47219.667 | 0.649708 | 0.598126 | 3.490295 |
| Oil and grease |  | 602.25 | 3 | 200.75 | 0.920344 | 0.460421 | 3.490295 |
| COD |  | 27089035.69 | 3 | 9029678.6 | 0.527136 | 0.671983 | 3.490295 |
| NH3-N |  | 461248.5 | 3 | 153749.5 | 1.478768 | 0.269902 | 3.490295 |
| BOD5 |  | 2955742.6 | 3 | 985247.56 | 0.583802 | 0.636958 | 3.490295 |
| Sulfate |  | 18345472.25 | 3 | 6115157.4 | 0.924674 | 0.458492 | 3.490295 |
| Sulfides |  | 74.58696875 | 3 | 24.862323 | 0.640345 | 0.603515 | 3.490295 |
| Chloride |  | 28855289.19 | 3 | 9618429.7 | 1.451611 | 0.276861 | 3.490295 |
| Fluoride |  | 8.493725 | 3 | 2.8312417 | 1.211414 | 0.347691 | 3.490295 |
| Ionic Detergents |  | 47.808125 | 3 | 15.936041 | 0.929381 | 0.456404 | 3.490295 |
| Total Chlorine |  | 0.012525 | 3 | 0.004175 | 1.034056 | 0.412408 | 3.490295 |
| Phenolic Compounds |  | 0.15554725 | 3 | 0.0518491 | 1.168943 | 0.36214 | 3.490295 |
| As |  | 0.001542 | 3 | 0.000514 | 2.026694 | 0.163916 | 3.490295 |
| Cd |  | 0.009219 | 3 | 0.003073 | 1.313446 | 0.315451 | 3.490295 |
| Cr |  | 0.032369 | 3 | 0.01079 | 0.679035 | 0.581518 | 3.490295 |
| Cu |  | 0.059025 | 3 | 0.019675 | 0.435328 | 0.731705 | 3.490295 |
| Fe |  | 49.90067 | 3 | 16.63356 | 1.145319 | 0.370453 | 3.490295 |
| Pb |  | 0.01416 | 3 | 0.00472 | 1.117352 | 0.380557 | 3.490295 |
| Mn |  | 17.69043 | 3 | 5.89681 | 0.669889 | 0.586653 | 3.490295 |
| Ni |  | 0.180269 | 3 | 0.06009 | 0.340889 | 0.79625 | 3.490295 |
| Zn |  | 71.7097 | 3 | 23.90323 | 6.554158 | 0.007137 | 3.490295 |
| Ba |  | 0.025771 | 3 | 0.00859 | 3.306285 | 0.057418 | 3.490295 |
| B |  | 48.0825 | 3 | 16.0275 | 0.994287 | 0.428585 | 3.490295 |
| CN |  | 0.386672 | 3 | 0.128891 | 2.682543 | 0.093871 | 3.490295 |
| TTm |  | 19.4052 | 3 | 6.468399 | 0.588395 | 0.634185 | 3.490295 |