Data Article

Ecotoxicity and genetic toxicity data from a pulp mill bleaching effluent treated with anaerobic digestion and advanced oxidation process (AOP)

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ABSTRACT

Wastewater treatment contributes to environmental sustainable development indicators such as clean water and sanitation, then, is imperative to improve the mechanisms and process of contaminant removals. The sewage and industrial effluents are the major contributors of pollutants in land and water discharges, and are necessary to enrich the available data for having reference parameters for plant designing and optimization. The physical and chemical assays alone could not be considered sufficient to assess properly the plant performance because complex mixtures demand ecological and biological parameters for a holistic evaluation. Hence, the ecotoxicity and the genetic toxicity measurement become an important tool to complement the conventional water quality parameters, but these parameters are not widely reported in the open access literature. Despite of several studies showed ecotoxicity and the genetic toxicity data, these could be considered not sufficient because the resulted information is derived from single compounds. Considering the scarce data mentioned above this article presents data on the genetic an ecological toxicity of an anaerobic effluent post-treated with ozone and ozone/UV generated by Chaparro et al. [1] and Chaparro and Pires [2].

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The Table 1 resumes the main values derived from the ecotoxicology assays and the Table 2 presents the main characteristic of these measurements. The raw data of the acute and chronic toxicity are shown in: Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19. The genetic toxicity was evaluated with the meristematic region of the Allium cepa L roots. The data is gathered in a Excel sheet file available in the Mendeley data website which can be found with the title "Ecotoxicity and genetic toxicity data (Allium cepa) from a bleaching wastewater treated on an anaerobic process and Ecotoxicity and genetic toxicity data of an anaerobic effluent pos-treated with ozone and ozone/UV respectively. Finally, Fig. 1 and Fig. 2 show images of the main genetic effects observed after the treatments.

1. Data

The Table 1 resumes the main values derived from the ecotoxicology assays and the Table 2 presents the main characteristic of these measurements. The raw data of the acute and chronic toxicity are shown in: Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19. The Genetic toxicity was evaluated considering the results of the Chromosome aberrations index (CA), variation of the mitotic index (IM) and mutagenic effects as number of micronucleus (MN). The data is gathered in a Excel sheet file available in the Mendeley data website which can be found with the title “Ecotoxicity and genetic toxicity data (Allium cepa) from a bleaching wastewater treated on an anaerobic process and “Ecotoxicity and genetic toxicity data of an anaerobic effluent pos-treated with ozone and ozone/UV” respectively. Finally, Fig. 1 and Fig. 2 show images of the main genetic effects observed after the treatments.

### Table 1
Main values of the Acute and Chronic toxicity.

| Treatment                | EC<sub>50</sub> | EC<sub>50</sub> | ICP<sub>(25)</sub> | ICP<sub>(25)</sub> |
|--------------------------|----------------|----------------|-------------------|-------------------|
| Raw WW                   | 5.47           | 7.42           | 4.93              | 5.52              |
| Anaerobic effluent       | 5.36–5.59      | 7.24–7.62      | 3.82              | Not available     |
| Anaerobic effluent       | 59.95          | 67.6           | 3.42–4.54         | 15.45–30.59       |
| Ozone effluent           | 52.71–68.20    | 61–74          | 16.22             | 18.31             |
| Ozone effluent           | 65.98          | 79.58          | 15.50–16.65       | 17.19–18.68       |
| O<sub>3</sub>/UV effluent| 60.12–72.41    | 76.47–82.84    | 16.41             | 13.79             |
| O<sub>3</sub>/UV effluent| 57.61–71.20    | 73.97–82.39    | 15.99–17.03       | 13.22–14.61       |
### Table 2
Main requirements for the maintenance of the cultures during the ecotoxicity assessment.

| Requirements                        | Daphnia similis | Ceriodaphnia dúbia/silvestrii |
|-------------------------------------|-----------------|-------------------------------|
| Assay                               | Static          | semi-static                   |
| Duration                            | 48 hours        | 7 days                        |
| Temperature                         | 20 ± 5 °C       |                               |
| Photoperiod/light intensity.        | 16h light: 8h dark 500–1000 lux | |
| Volume of samples                   | 10 mL           | 15 mL                         |
| Minimum number of dilutions with replicates | Five more controls | |
| Number of replicates per dilution.  | 4               | 10                            |
| Feeding                             | Not             | Yes                           |
| Water of dilution                   | Reconstituted water tank | |
| Test organism age                   | 6h–24h          |                               |
| Number of organisms per replicate   | 5               | 1                             |
| Renewal of the test solution        | Not             | Every 2 days                  |
| Evaluation criteria                 | Mortality/Immobility | Reproduction/Survival        |
| Test Acceptance Criteria            | >90% survival of organisms in the control | >80% survival and >15 neonates/female control. |

### Table 3
Acute toxicity of industrial bleaching effluent (test 1).

| Sample | Concentration (%) | number exposed | Mortalities a |
|--------|-------------------|----------------|---------------|
| 1      | 5                 | 20             | 0             |
| 2      | 5.8               | 20             | 18            |
| 3      | 6.9               | 20             | 20            |
| 4      | 8.8               | 20             | 20            |
| 5      | 10                | 20             | 20            |

a Statistical validation. Spearman-Karber trim = 0; Spearman-Karber estimates = eC50 = 5.472590; lower confidence interval (95%) = 5.36; upper confidence interval (95%) = 5.59.

### Table 4
Acute toxicity of industrial bleaching effluent (test 2).

| Sample | Concentration (%) | number exposed | Mortalities a |
|--------|-------------------|----------------|---------------|
| 1      | 5.7               | 20             | 0             |
| 2      | 6.9               | 20             | 2             |
| 3      | 8.3               | 20             | 20            |
| 4      | 10                | 20             | 20            |

a Statistical validation. Spearman-Karber trim = 0; Spearman-Karber estimates = eC50 = 7.4268293; lower confidence interval (95%) = 7.24; upper confidence interval (95%) = 7.62.

### Table 5
Chronic Toxicity of industrial bleaching effluent (test 1).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooled a mean response |
|--------|----------------------|-------------------|---------------|--------------------|------------------------|
| 1      | 10                   | 0                 | 13.5          | 3.064              | 13.5                   |
| 2      | 10                   | 3.8               | 12.3          | 6.977              | 12.3                   |
| 3      | 10                   | 4.5               | 11.6          | 7.106              | 11.6                   |
| 4      | 10                   | 5.4               | 10.3          | 6.516              | 10.3                   |
| 5      | 10                   | 6.5               | 8.7           | 4.498              | 8.7                    |

a Statistical validation. Linear Interpolation Estimate = 5.5203; Entered P Value = 25; number of resampling = 80; Resamples Generated = 71, those resamples not used had estimates above the highest concentration; The Bootstrap Estimates Mean = 4.9619; standard deviation = 0.9109; No Confidence Limits can be produced since the number of resamples generated is not a multiple of 40; resampling time in Seconds = 0.00; random Seed: 435879320.
The raw industrial wastewater was obtained from a kraft pulp mill with ECF sequence (Elemental Chlorine Free) located in Sao Paulo state—Brazil. Further information about the characteristics of this effluent can be found in Chaparro and Pires [3]. The pulp mill was treated biologically in a horizontal anaerobic immobilized biomass reactor (HAIB) for 306 days with an organic volumetric load of 2.33 kgCOD/m³.day and an hydraulic retention time of 25 h. The effluent from this reactor was subjected to ozone and ozone/UV oxidation tests without prior pH adjustment. The pH of the HAIB reactor effluent

2. Experimental design, materials, and methods

The raw industrial wastewater was obtained from a kraft pulp mill with ECF sequence (Elemental Chlorine Free) located in Sao Paulo state—Brazil. Further information about the characteristics of this effluent can be found in Chaparro and Pires [3]. The pulp mill was treated biologically in a horizontal anaerobic immobilized biomass reactor (HAIB) for 306 days with an organic volumetric load of 2.33 kgCOD/m³.day and an hydraulic retention time of 25 h. The effluent from this reactor was subjected to ozone and ozone/UV oxidation tests without prior pH adjustment. The pH of the HAIB reactor effluent
was close to 8.6. The samples were taken at regular intervals during the experimental period to evaluate the ecotoxicity and the genetic toxicity. Ecotoxicity assays were conducted according to the Brazilian standards [4,5], which were expressed in acute and chronic toxicity units using the linear interpolation method [6,7]. Table 2 shows a brief summary of the main requirements for the acute and chronic toxicity bioassays.

### Table 10
Chronic Toxicity of HAIB reactor effluent (test 3).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooled mean response |
|--------|----------------------|-------------------|---------------|--------------------|----------------------|
| 1      | 9                    | 0                 | 7.667         | 1.323              | 7.667                |
| 2      | 10                   | 12.5              | 1.4           | 1.35               | 1.4                 |
| 3      | 10                   | 25                | 0             | 0                  | 0                   |

* a Statistical validation. Linear Interpolation Estimate = 3.8231; Entered P Value = 25; number of resampling = 80; Resamples Generated = 80, those resamples not used had estimates above the highest concentration; The Bootstrap Estimates Mean = 3.8683; standard deviation = 0.2846; resampling time in Seconds = 0.00; random Seed: -181298520.

### Table 11
Chronic Toxicity of HAIB reactor effluent (test 3).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooled mean response |
|--------|----------------------|-------------------|---------------|--------------------|----------------------|
| 1      | 10                   | 0                 | 11.1          | 6.999              | 12.824               |
| 2      | 7                    | 11.85             | 15.286        | 5.345              | 12.824               |
| 3      | 10                   | 17.7              | 9.8           | 5.673              | 9.9                  |
| 4      | 10                   | 26.6              | 10            | 6.146              | 9.9                  |
| 5      | 10                   | 40                | 2.1           | 2.807              | 2.1                  |

* a Statistical validation. Linear Interpolation Estimate = 27.0851; Entered P Value = 25; number of resampling = 80; Resamples Generated = 80; the Bootstrap Estimates Mean = 23.1732; standard deviation = 5.4741; resampling time in Seconds = 0.00; random Seed: -1470801740. lower confidence interval (95%) = 15.4527; upper confidence interval (95%) = 30.5956.

### Table 12
Acute toxicity of industrial bleaching effluent treated with ozone/UV (test 1).

| Sample | Concentration (%) | number exposed | Mortalities |
|--------|-------------------|----------------|-------------|
| 1      | 6.25              | 20             | 0           |
| 2      | 12.50             | 20             | 0           |
| 3      | 25.00             | 20             | 0           |
| 4      | 50.00             | 21             | 3           |
| 5      | 100.00            | 20             | 20          |

* a Statistical validation. Spearman-Karber trim = 0; Spearman-Karber estimates = eC50 64.04; lower confidence interval (95%) = 57.61; upper confidence interval (95%) = 71.20.

### Table 13
Acute toxicity of industrial bleaching effluent treated with ozone/UV (test 2).

| Sample | Concentration (%) | number exposed | Mortalities |
|--------|-------------------|----------------|-------------|
| 1      | 20.00             | 20             | 0           |
| 2      | 30.00             | 20             | 0           |
| 3      | 44.00             | 19             | 0           |
| 4      | 66.00             | 20             | 2           |
| 5      | 100.00            | 20             | 20          |

* a Statistical validation. Spearman-Karber trim = 0; Spearman-Karber estimates = eC50 77.97; lower confidence interval (95%) = 73.79; upper confidence interval (95%) = 82.39.
Table 14
Acute toxicity of industrial bleaching effluent treated with ozone (test 1).

| Sample | Concentration (%) | number exposed | Mortalitiesa |
|--------|-------------------|----------------|--------------|
| 1      | 6.25              | 20             | 0            |
| 2      | 12.50             | 20             | 0            |
| 3      | 25.00             | 20             | 0            |
| 4      | 50.00             | 20             | 2            |
| 5      | 100.00            | 20             | 20           |

a Statistical validation. Spearman-Karber trim = 0; Spearman-Karber estimates = eC50 65.97; lower confidence interval (95%) = 60.12; upper confidence interval (95%) = 72.41.

Table 15
Acute toxicity of industrial bleaching effluent treated with ozone (test 2).

| Sample | Concentration (%) | number exposed | Mortalitiesa |
|--------|-------------------|----------------|--------------|
| 1      | 20.00             | 19             | 0            |
| 2      | 30.00             | 20             | 0            |
| 3      | 44.00             | 18             | 0            |
| 4      | 66.00             | 20             | 1            |
| 5      | 100.00            | 20             | 20           |

a Statistical validation. Spearman-Karber trim = 0; Spearman-Karber estimates = eC50 79.59; lower confidence interval (95%) = 76.47; upper confidence interval (95%) = 82.84.

Table 16
Chronic Toxicity of industrial bleaching effluent treated with ozone (test 1).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooleda mean response |
|--------|----------------------|-------------------|---------------|--------------------|-----------------------|
| 1      | 9                    | 0                 | 7.67          | 1.323              | 8.68                  |
| 2      | 10                   | 12.50             | 9.60          | 4.40               | 8.68                  |
| 3      | 10                   | 25.00             | 1.40          | 1.51               | 1.40                  |

a Statistical validation. Linear Interpolation Estimate = 16.2256; Entered P Value = 25; number of resampling = 80; Resamples Generated = 80; The Bootstrap Estimates Mean = 16.1503; standard deviation = 0.3784; lower confidence interval (95%) = 15.5014; upper confidence interval (95%) = 16.6576. resampling time in Seconds = 0.00; random Seed: -347644830.

Table 17
Chronic Toxicity of industrial bleaching effluent treated with ozone (test 2).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooleda mean response |
|--------|----------------------|-------------------|---------------|--------------------|-----------------------|
| 1      | 10                   | 0                 | 12.6          | 2.989              | 13                    |
| 2      | 10                   | 15.8              | 13.4          | 4.624              | 13                    |
| 3      | 10                   | 23.7              | 2.8           | 2.348              | 2.8                   |
| 4      | 10                   | 35.55             | 1.1           | 0.876              | 1.1                   |

a Statistical validation. Linear Interpolation Estimate = 18.3172; Entered P Value = 25; number of resampling = 80; Resamples Generated = 80; The Bootstrap Estimates Mean = 18.1233; standard deviation = 0.7975; lower confidence interval (95%) = 17.1929; upper confidence interval (95%) = 18.6884. resampling time in Seconds = 0.00; random Seed: -27183750.

Table 18
Chronic Toxicity of industrial bleaching effluent treated with ozone/UV (test 1).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooleda mean response |
|--------|----------------------|-------------------|---------------|--------------------|-----------------------|
| 1      | 9                    | 0                 | 7.667         | 1.323              | 8.421                 |
| 2      | 10                   | 12.5              | 9.1           | 2.644              | 8.421                 |
| 3      | 10                   | 25                | 1.7           | 1.829              | 1.7                   |

a Statistical validation. Linear Interpolation Estimate = 16.4154; Entered P Value = 25; number of resampling = 80; Resamples Generated = 80; The Bootstrap Estimates Mean = 16.3993; standard deviation = 0.3723; lower confidence interval (95%) = 15.9225; upper confidence interval (95%) = 17.0320. resampling time in Seconds = 0.00; random Seed: -5333658.
Table 19
Chronic Toxicity of industrial bleaching effluent treated with ozone/UV (test 2).

| Sample | Number of Replicates | Concentration (%) | Mean response | Standard deviation | Pooled mean response |
|--------|----------------------|-------------------|--------------|--------------------|----------------------|
| 1      | 10                   | 0                 | 12.6         | 2.989              | 15.85                |
| 2      | 10                   | 10                | 19.1         | 7.43               | 15.85                |
| 3      | 10                   | 20                | 5.4          | 2.797              | 5.4                  |
| 4      | 10                   | 40                | 0            | 0                  | 0                    |

*a* Statistical validation. Linear Interpolation Estimate = 13.7919; Entered P Value = 25; number of resampling = 80; Resamples Generated = 80; The Bootstrap Estimates Mean = 13.8374; standard deviation = 0.5653; lower confidence interval (95%) = 13.2224; upper confidence interval (95%) = 14.6104. resampling time in Seconds = 0.00; random Seed: -119261604.

Fig. 1. Cells in root tips of *Allium cepa* exposed with bleaching effluents and the HAIB reactor. (a) normal cellular division, anaphase, metaphase, interphase. (b) Disturbed metaphase with break. (c) Telophase with bridge. (d) Anaphase with loss and bridge. (e) Micronucleus. (f) Binucleus cells and multiple nuclear lesions.
The genetic toxicity was performed according to the modified version of the Grant’s protocol [8]. The Genotoxicity index was evaluated based on the Chromosome aberrations (CA), Cytotoxicity was calculated through the mitotic index (MI) and the Mutagenic effect was assessed based on the micronucleus (MN) as follows:

\[ CA = \frac{\text{number of cells with CA}}{\text{total number of observed cells}} \times 100 \]  

\[ MI = \frac{\text{number of dividing cells}}{\text{total number of observed cells}} \times 100 \]  

\[ MN = \frac{\text{number of cells with MN}}{\text{total number of observed cells}} \times 100 \]  

Fig. 2. Cells in root tips of *Allium cepa* exposed with ozone and ozone/UV (a) Telophase with bridge and anaphase with bridge and break. b) Metaphase with loss. C) Vacuolized cell.

The genetic toxicity was performed according to the modified version of the Grant’s protocol [8]. The Genotoxicity index was evaluated based on the Chromosome aberrations (CA), Cytotoxicity was calculated through the mitotic index (MI) and the Mutagenic effect was assessed based on the micronucleus (MN) as follows:

\[ CA = \frac{\text{number of cells with CA}}{\text{total number of observed cells}} \times 100 \]  

\[ MI = \frac{\text{number of dividing cells}}{\text{total number of observed cells}} \times 100 \]  

\[ MN = \frac{\text{number of cells with MN}}{\text{total number of observed cells}} \times 100 \]
Finally, the statistical analysis considered the non-parametric Kruskal–Wallis applied by means of the BioEstat 5.0 software (https://bioestat.software.informer.com/5.0/).

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105141.

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