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Abstract
Removal of synthetic dyes from wastewater generated by the textile industries is important. Rhodamine-B is widely used colorant and is medically proven to lead to tissue borne sarcoma, reproductive and neurotoxicity issues in humans, if still present in the treated drinking water. Herein, this dataset provides information on different forms of sand materials for their effective utilization as an adsorbent material for Rhodamine-B. The effectiveness of the media was measured in terms of breakthrough time obtained. One of the 27 presented data set is a part of a research article [1] explaining the breakthrough time of these filter media under specific experimental condition. All these data is a combination of three variables that were studied: a) concentration of Rhodamine-B (1 mg/L, 5 mg/L and 10 mg/L), b) flow velocity of Rhodamine-B spiked water (2 mL/min, 5 mL/min and 10 mL/min) and c) bed height (7.5 cm, 10 cm, and 12.5 cm). At any bed height, the breakthrough time of graphitized sand (brewery sugar coated,
GS1) was found to be 3–4 times higher than the second best adsorbent, i.e., manganese dioxide coated on GS1.

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1. Data

The dataset comprises experimental data that were obtained for all the six filter adsorbents in terms of their breakthrough time period at the specified concentration of the adsorbate (3-levels, more detail in section 2), bed height of the adsorbent (3-levels, more detail in section 2) and flow through velocity.

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**Specifications Table**

| Subject area | Chemical Engineering |
|--------------|----------------------|
| More specific subject area | Filtration and separation |
| Type of data | Tables |
| How data was acquired | Spectrophotometer reading of 96-well plates at a wavelength of 550 nm. A calibration graph was plotted based on the standard (known) concentration of Rhodamine-B (adsorbate) and the optical density to determine the filtered Rhodamine-B concentration. The breakthrough time (effluent concentration becomes 5% of initial adsorbate concentration) was noted. |
| Data format | Raw data as obtained from the experimental observation and predicted value from bed depth service time model equation |
| Experimental factors | Variables: a) concentration of adsorbate, b) flow velocity of influent to the filter containing adsorbent and c) bed height of adsorbent in the filter column |
| Adsorbents: | Raw sand (RS), Graphitized sand using brewery effluent as the sugar source (GS1), Graphitized sand using sucrose as the sugar source (GS2), manganese dioxide impregnated raw sand (RSMN) and graphitized sand (GS1M, GS2M) |
| Experimental features | Data of breakthrough time using different sand forms such as raw sand, graphitized sand, manganese-coated sand. A laboratory-scale model filter column was used for the filtration experiments. |
| Data source location | INRS-ETE, Université du Québec, 490, Rue de la Couronne, Québec, Canada G1K 9A9 |
| Data accessibility | Data presented in these articles |
| Related research article | Kumar, P., Rehab, H., Hegde, K., Brar, S. K., Cledon, M., Kermanshahi-pour, A., . . . Surampalli, R. Y. (2020). Physical and biological removal of Microcystin-LR and other water contaminants in a biofilter using Manganese Dioxide coated sand and Graphene sand composites. Science of The Total Environment, 703. doi: https://doi.org/10.1016/j.scitotenv.2019.135052 [1]. |

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**Value of the Data**

- The dataset presented in this article summarizes the breakthrough time of six different filter media used as an adsorbent material. The data set will help researchers to get insight into the different filter media that can prove as an alternative to the raw sand media (conventionally used).
- A more in-depth comparison can be made as to the data deals with three prominent variables (flow rate, adsorbate concentration, and adsorbent bed height) that are expected for any filter adsorbent studies. These variables will help the water treatment scientists to explore more possibilities for its utility.
- Overall, this dataset can expedite the scientific community in gathering more insights into various other filter adsorbents apart from conventional sand media that proved to be more effective in adsorbing Rhodamine-B (adsorbate).
- These data in the form of breakthrough time can set a benchmark for adsorption study of other micropollutants as well where reference to this dataset can be made in the future to support the technical explanation.
- Any scale-up filter column study using these filter media can be extrapolated using these data as they closely fit with the bed-depth service time model (BDST). This model is widely applied to predict the breakthrough time under different experimental conditions in a filter column study.

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1. Data

The dataset comprises experimental data that were obtained for all the six filter adsorbents in terms of their breakthrough time period at the specified concentration of the adsorbate (3-levels, more detail in section 2), bed height of the adsorbent (3-levels, more detail in section 2) and flow through velocity.
Table 1 tabulates breakthrough time data for an initial adsorbate (Rhodamine-B) concentration of 1 mg/L for all six adsorbents. Similarly, Table 2 and Table 3 tabulates the breakthrough time period for the initial adsorbate (Rhodamine-B) concentration of 5 mg/L and 10 mg/L, respectively for all six adsorbents.

2. Experimental design, materials, and methods

2.1. Preparation of adsorbent media used

The preparation method for obtaining graphitized-sand (GS1 and GS2) and manganese-coated sand (RSMN, GS1M, and GS2M) is described by Gupta et al., 2012 [2] and Jia et al. (2015) [3], respectively. Raw sand (quartz sand) was obtained from Chemin Ste-Foy DWTP, Quebec City, Canada. The sugar solution (brewery effluent for GS1 and sucrose for GS2) was prepared according to strength 0.1g/g-sand and was caromalized at 186 °C followed by graphitization at 600 °C for 3 hours under reduced atmospheric condition. To obtain GS1M and GS2M, potassium permanganate (7%, w/v) was melted (240 °C) over the graphitized sand and kept for 3 hours before washing and drying them at room temperature overnight.

2.2. Breakthrough time study

Rhodamine-B was prepared in three different concentration viz. 1 mg/L, 5 mg/L, and 10 mg/L. Other two variables were bed height of the adsorbents: 7.5 cm, 10 cm, 12.5 cm, and linear flow through velocity: 2 mL/min, 5 mL/min and 10 mL/min. Hence, a total of 27 different experimental combinations were obtained for each of the six adsorbents. The filter column used for the adsorption experiment has an internal diameter of 2.3 cm and a total height of 20 cm. After the passage of every 40 mL (~twice the bed volume) at a specific flow rate and bed height, the optical density (OD) of the collected filtered-

| Bed Depth | Conditions | RS | RSMN | GS1 | GS2 | GS1MN | GS2MN |
|-----------|------------|----|------|-----|-----|-------|-------|
| Z = 7.5 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb (min)    | 3.67 | 4.08 | 51  | 4.67 | 21   | 5     |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78  |
|           | Tb (min)    | 59  | 80   | 5007| 377 | 1678 | 431   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31  |
|           | Tb (min)    | 227 | 310  | 8040| 1508| 6702 | 1721  |
| Z = 10 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56  |
|           | Tb (min)    | 22  | 29   | 1702| 129 | 573  | 147   |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78  |
|           | Tb (min)    | 96  | 131  | 8312| 626 | 2782 | 714   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31  |
|           | Tb (min)    | 320 | 438  | 10355| 2133| 9481 | 2435  |
| Z = 12.5 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56  |
|           | Tb predicted (min) | 41 | 55 | 3355 | 253 | 1126 | 289   |
|           | Tb observed (min) | 36 | 59 | 3165 | 238 | 1078 | 265   |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78  |
|           | Tb predicted (min) | 133 | 181 | 11617| 874 | 3887 | 998   |
|           | Tb observed (min) | 125 | 195 | 10584| 901 | 3387 | 967   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31  |
|           | Tb predicted (min) | 413 | 565 | 36671| 2758| 12260| 3149  |

Tb = Breakthrough Time; Uo = Linear flow through velocity; Z = Bed depth; RS: Raw sand; RSMN: Raw sand manganese; GS1: Brewery solution sugar coated sand; GS2: Sucrose solution coated sand; GS1M and GS2M: Manganese dioxide-coated graphitized sand from respective sugar sources.
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fluent underwent spectrophotometric reading at the wavelength of 550 nm. All the tests were repeated 3 times. Based on the standardized relationship obtained between OD and initial Rhodamine-B (adsorbate) concentration (Co), the effluent concentration (Ct) was determined. At Ct/Co ratio of 0.05, the time was noted and is referred to as the ‘breakthrough time period’.

Table 2
Breakthrough time data for all the adsorbent material at the initial adsorbate (Rhodamine-B) concentration of 5 mg/L.

| Bed Depth | Conditions | RS | RSMN | GS1 | GS2 | GS1MN | GS2MN |
|-----------|------------|----|------|-----|-----|-------|-------|
| Z = 7.5 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb (min)   | 0.74 | 0.82 | 1.0 | 0.94 | 4.2 | 1.0 |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Tb (min)   | 12  | 16   | 1001 | 75  | 336  | 86   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
|           | Tb (min)   | 45  | 62   | 4008 | 302 | 1340 | 344  |
| Z = 10 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb (min)   | 4   | 6    | 340  | 26  | 115  | 29   |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Tb (min)   | 19  | 26   | 1662 | 125 | 556  | 143  |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
|           | Tb (min)   | 64  | 88   | 5671 | 427 | 1896 | 487  |
| Z = 12.5 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb (min)   | 8   | 11   | 671  | 51  | 225  | 58   |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Tb (min)   | 27  | 36   | 2323 | 175 | 777  | 200  |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
|           | Tb (min)   | 83  | 113  | 7334 | 552 | 2452 | 630  |

Tb= Breakthrough Time; Uo = Linear flow through velocity; Z = Bed depth; RS: Raw sand; RSMN: Raw sand manganese; GS1: Brewery solution sugar coated sand; GS2: Sucrose solution coated sand; GS1M and GS2M: Manganese dioxide-coated graphitized sand from respective sugar sources.

Table 3
Breakthrough time data for all the adsorbent material at the initial adsorbate (Rhodamine-B) concentration of 10 mg/L.

| Bed Depth | Conditions | RS | RSMN | GS1 | GS2 | GS1MN | GS2MN |
|-----------|------------|----|------|-----|-----|-------|-------|
| Z = 7.5 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb (min)   | 0.37 | 0.41 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Tb (min)   | 6   | 8    | 501  | 38  | 168  | 43   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
|           | Tb (min)   | 23  | 31   | 2004 | 151 | 670  | 172  |
| Z = 10 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb (min)   | 2   | 3    | 170  | 13  | 57   | 15   |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Tb (min)   | 10  | 13   | 831  | 63  | 278  | 71   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
|           | Tb (min)   | 32  | 44   | 2836 | 213 | 948  | 244  |
| Z = 12.5 cms | Uo (cm/min) | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 | 1.56 |
|           | Tb predicted (min) | 4   | 5   | 335  | 25  | 113  | 29   |
|           | Tb observed (min) | 4   | 5   | 311  | 22  | 101  | 32   |
|           | Uo (cm/min) | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
|           | Tb predicted (min) | 13  | 18  | 1162 | 87  | 389  | 100  |
|           | Tb observed (min) | 14  | 21  | 1098 | 92  | 356  | 99   |
|           | Uo (cm/min) | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
|           | Tb predicted (min) | 41  | 56  | 3667 | 276 | 1226 | 315  |

Tb= Breakthrough Time; Uo = Linear flow through velocity; Z = Bed depth; RS: Raw sand; RSMN: Raw sand manganese; GS1: Brewery solution sugar coated sand; GS2: Sucrose solution coated sand; GS1M and GS2M: Manganese dioxide-coated graphitized sand from respective sugar sources.
It was observed that for the specific initial Rhodamine-B concentration and flow rate, the relationship between the bed height and breakthrough time followed the bed-depth service time model (BDST model). The model is represented in the form of Equation (1) as under:

$$T_b = \frac{N_0 Z}{UoCo} \frac{1}{k_{bd} C_0} \ln \left( \frac{C_0}{C_0} - 1 \right)$$

where $N_0$ is the saturation concentration per unit bed volume (mg/L), $Z$ is the bed height, $C_0$ is influent concentration, $U_0$ is flow through velocity, $k_{bd}$ is the adsorption rate constant (L/mg.min) and $C_B$ is the concentration of adsorbate at the breakpoint.

It can be observed from Tables 1–3 that as the bed depth increases, there is an increase in breakthrough time ($T_b$) as well, while $T_b$ decreases as the initial concentration of Rhodamine-B increases. Overall the trend of breakthrough time followed the order: RS < RSMN < GS2 < GS2M < GS1M < GS1 where GS1 showed almost three times more $T_b$ than second best adsorbent, i.e., GS1M (for any similar chosen experimental condition). All the filter media performed better than the raw sand attributing an increase in roughness, active adsorption sites and surface area thereby assisting more Rhodamine-B molecule adsorption [4]. Tables 1–3 also shows the predicted breakthrough time using BDST model at highest bed depth value of 12.5 cm under all three flow rates (10 mL/min, 5 mL/min and 2 mL/min) and under every different initial Rhodamine-B concentration (1 mg/L, 5 gm/L and 10 mg/L). These predicted values were compared with the observed experimental values to cross-check the linearity of the BDST model. The experimental and the predicted values are mentioned in Tables 1–3. The kinetics data of these adsorbents in relation to the metal adsorption has been mentioned in Kumar et al. (2020) [1].

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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.

References

[1] P. Kumar, H. Rehab, K. Hegde, S.K. Brar, M. Cledon, A. Kermanshahi–pour, S. Vo Duy, S. Sauvé, R.Y. Surampalli, Physical and biological removal of Microcystin-LR and other water contaminants in a biofilter using Manganese Dioxide coated sand and Graphene sand composites, Sci. Total Environ. 703 (2019). https://doi.org/10.1016/j.scitotenv.2019.135052.

[2] S.S. Gupta, T.S. Sreeprasad, S.M. Maliyekkal, S.K. Das, T. Pradeep, Graphene from sugar and its application in water purification, ACS Appl. Mater. Interfaces 4 (8) (2012) 4156–4163, https://doi.org/10.1021/am300889u.

[3] H. Jia, J. Liu, S. Zhong, F. Zhang, Z. Xu, X. Gong, C. Lu, Manganese oxide coated river sand for Mn(II) removal from groundwater, J. Chem. Technol. Biotechnol. 90 (9) (2015) 1727–1734, https://doi.org/10.1002/jctb.4524.

[4] S. Han, K. Liu, L. Hu, F. Teng, P. Yu, Y. Zhu, Superior adsorption and regenerable dye adsorbent based on flower-like molybdenum disulfide nanostructure, Sci. Rep. 7 (1) (2017), https://doi.org/10.1038/srep43599.