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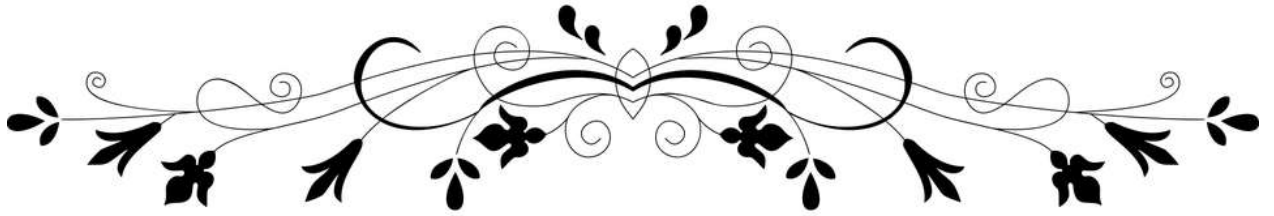
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***APPENDIX***

## Appendix A

### Appendix A-1. Sequence of *Exiguobacterium* sp. RKS3 (MG696729.1).

TGGTAGTTCACGCCGTAACGATGAGTGCTAGGTGTTGGAGGGTTCCGCCCTTCAGTGCTG  
AAGCTAACGCATTAAGCACTCCGCCTGGGGAGTACGGTCGCAAGGCTGAACTCAAAGGAA  
TTGACGGGGACCCGCACAAGCGGTGGAGCATGTGGTTAATTTCGAAGCAACGCGAAGAACC  
TTACCAACTCTTGACATCCCCCTGACCGGTACAGAGATGTACCTTCCCCTTCGGGGGCAGGG  
GTGACAGGTGGTGCATGTTGTCGTCAGCTCGTGTGTCGTGAGATGTTGGGTTAAGTCCCGCAA  
CGAGCGCAACCCTTGTCTTAGTTGCCAGCATTTGGTTGGGCACTCTAAGGAGACTGCCGGT  
GACAAACCGGAGGAAGGTGGGGATGACGTCAAATCATCATGCCCTTATGAGCTGGGCTAC  
ACACGTGCTACAATGGACGGTACAAAGGGCAGCGAAGCCGCGAGGTGGAGCCAATCCAG  
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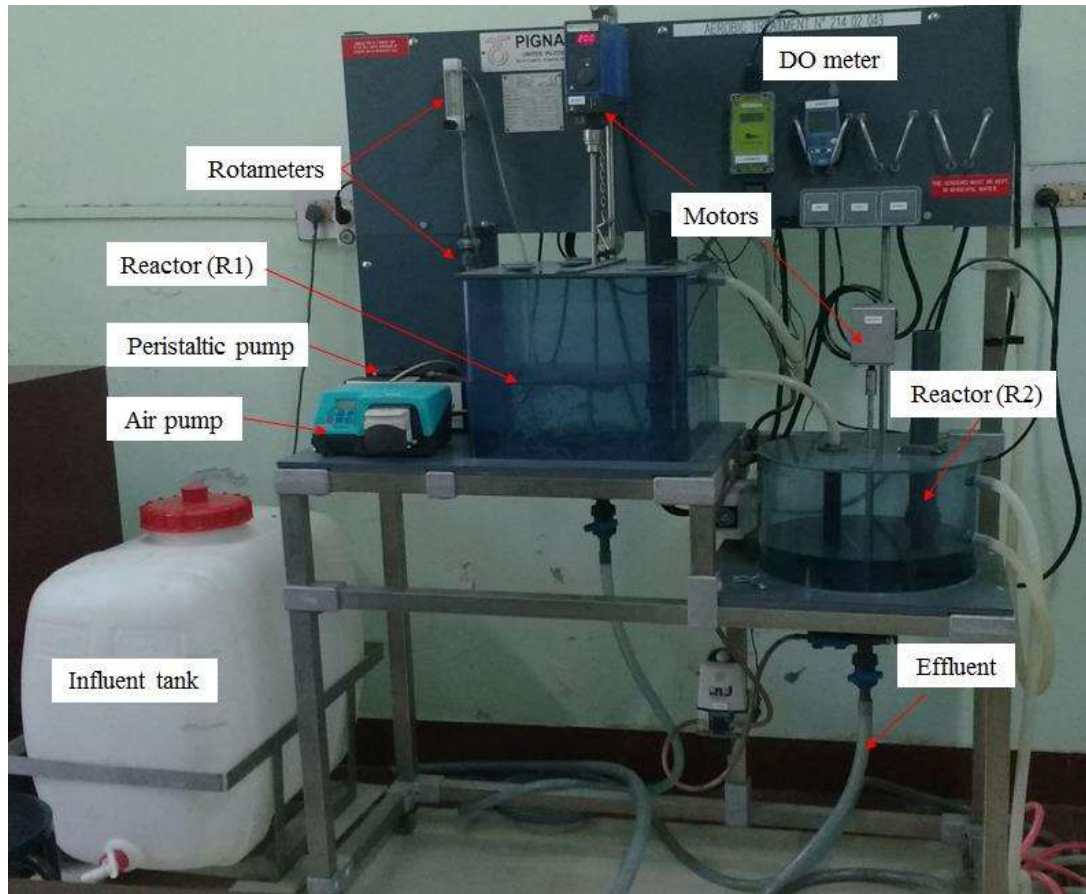
### Appendix A-2. Sequence of *Bacillus cereus* RKS4 (MH681588.1).

AGGGGGGGGGCGGGGTGGGCGGAAGGGCGATGTTCTGGTCTGTAACTGACACTGAGGGCG  
GAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAACGCATGAGTG  
CTAAGTGTTAGAGGGTTTCCGCCCTTAGTGCTGAAGTTAACGCATTAAGCACTCCGCCTGG  
GGAGTACGGCCGCAAGGCTGAACTCAAAGGAATTGACGGGGGCCCGACAAGCGGTGGA  
GCATGTGGTTAATTTCGAAGCAACGCGAAGAACCCTACCAGGTCTTGACATCCTCTGACAAC  
CCTAGAGATAGGGCTTCTCCTTCGGGAGCAGAGTGACAGGTGGTGCATGGTTGTCGTCAGCT  
CGTGTGTCGTGAGATGTTGGGTTAAGTCCCGCAAACGAGCGCAACCCTTGATCTTAGTTGCCATC  
ATTAAGTTGGGCACTCTAAGGTGACTGCCGGTGACAAACCGGAGGAAGGTGGGGATGACGT  
CAAATCATCATGCCCTTATGACCTGGGCTACACACGTGCTACAATGGACGGTACAAAGAG  
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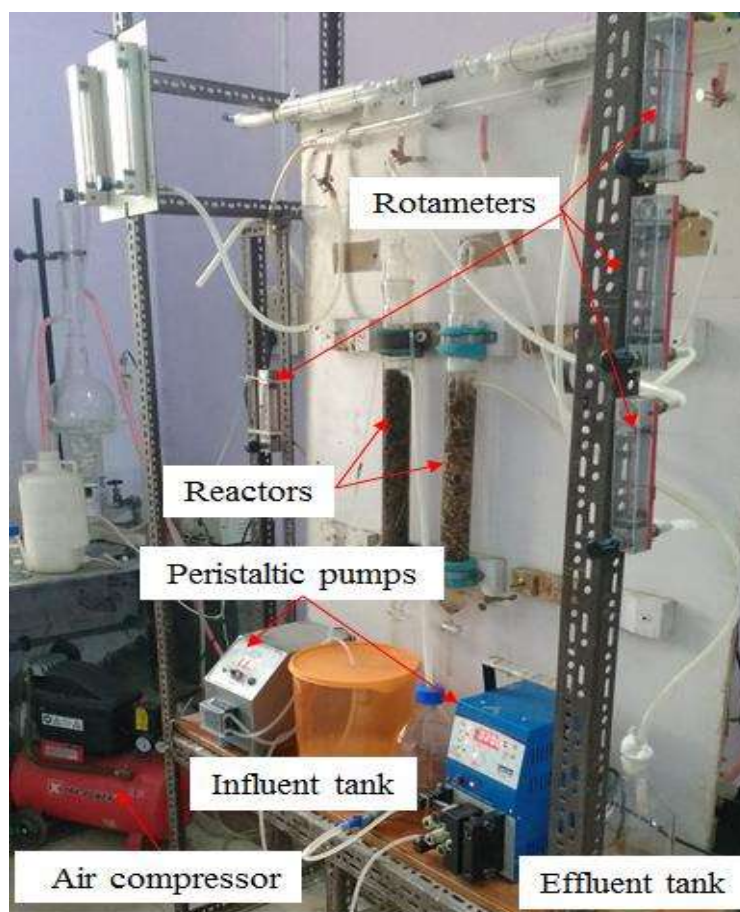
### Appendix A-3. Sequence of *Bacillus* sp. IITBHU (MH587030.1).

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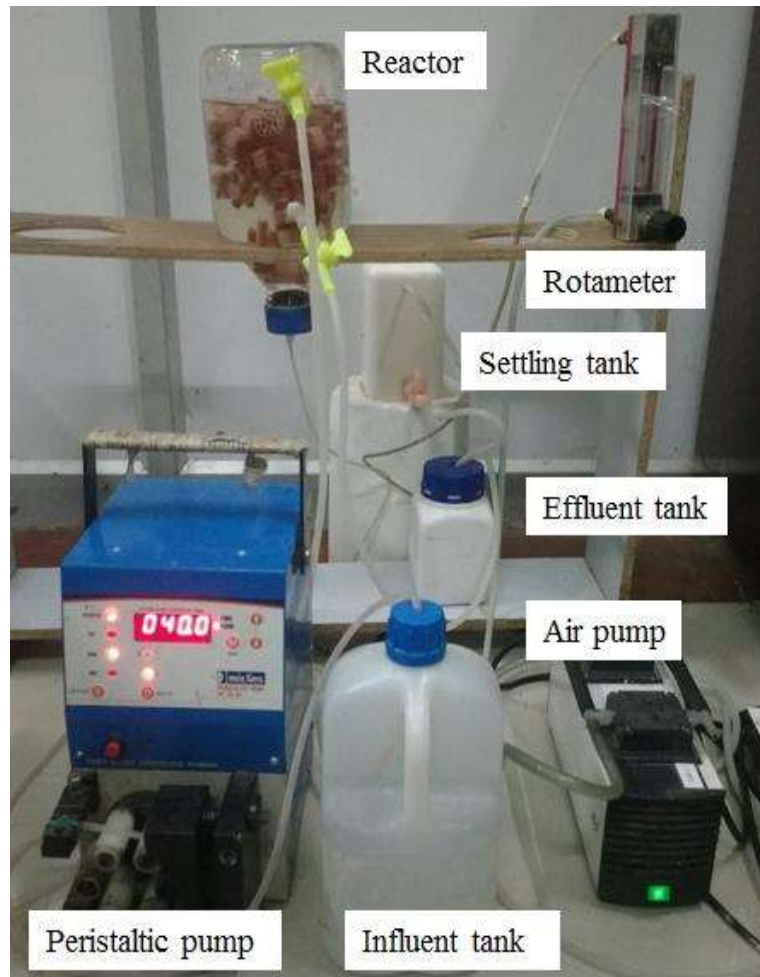
## Appendix B



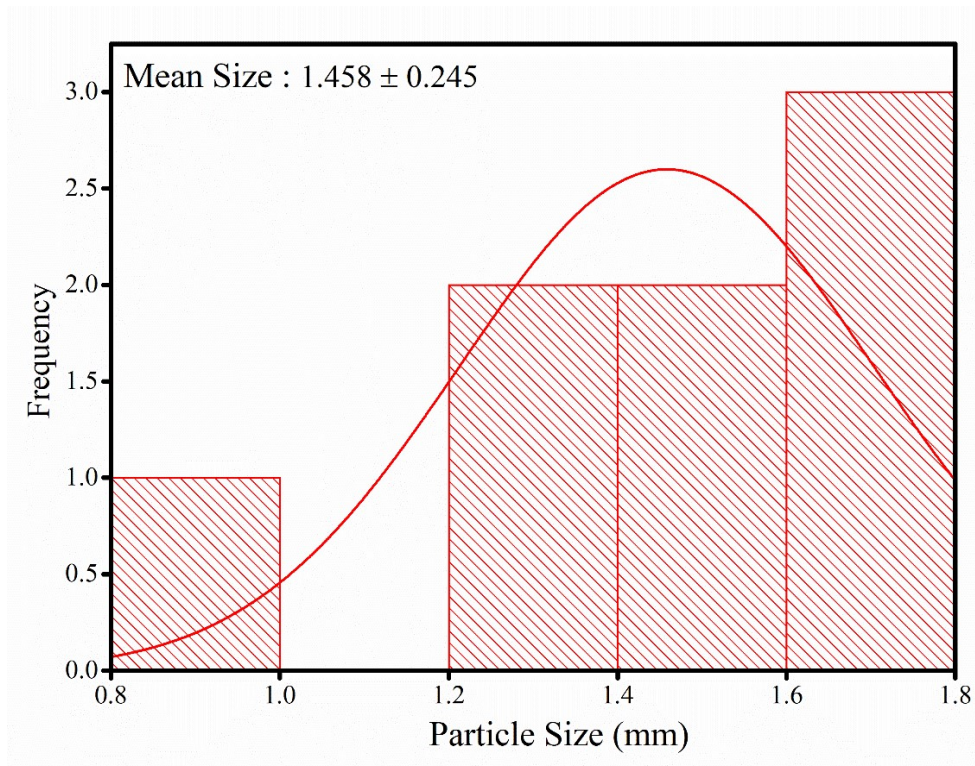
**Figure B-1.** Experimental setup of a pilot-scale integrated aerobic treatment plant.



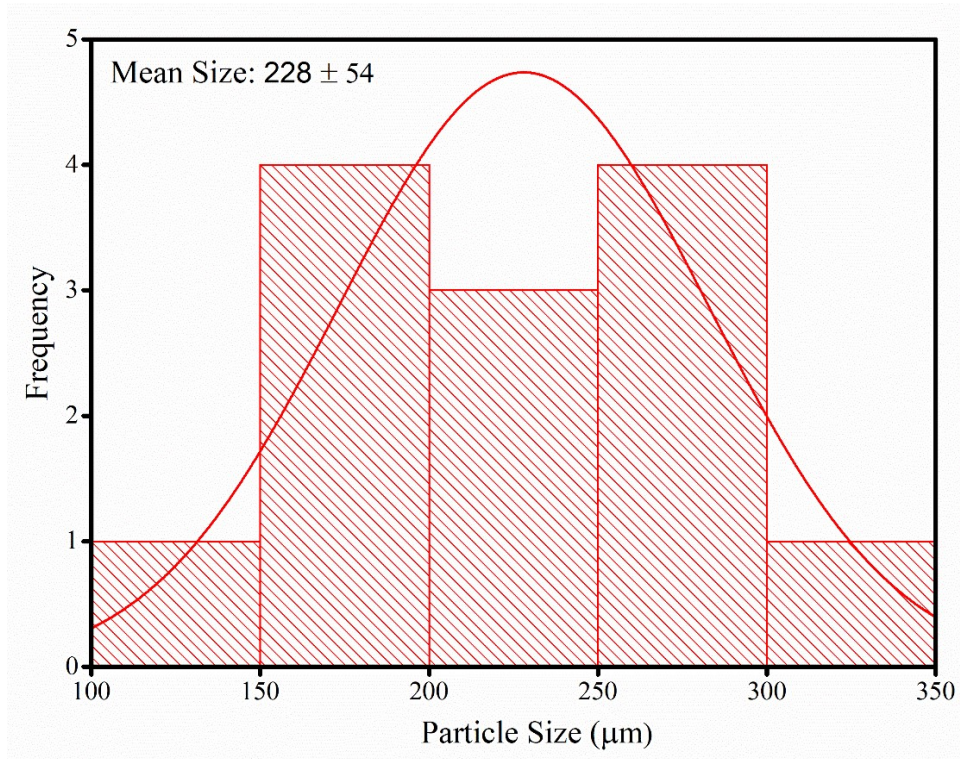
**Figure B-2.** Experimental setup of a packed bed bioreactor.



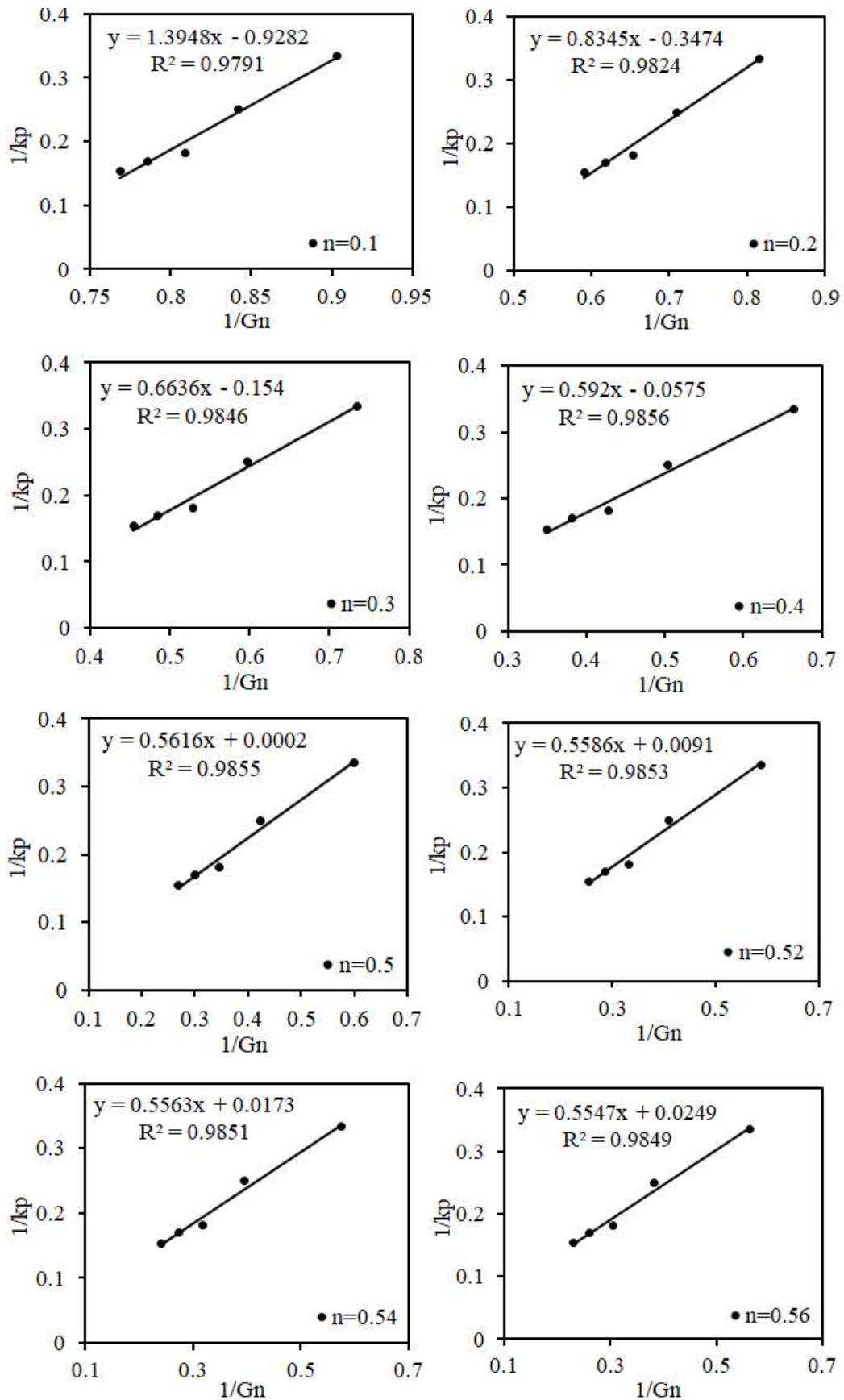
**Figure B-3.** Experimental setup of a moving bed biofilm reactor.

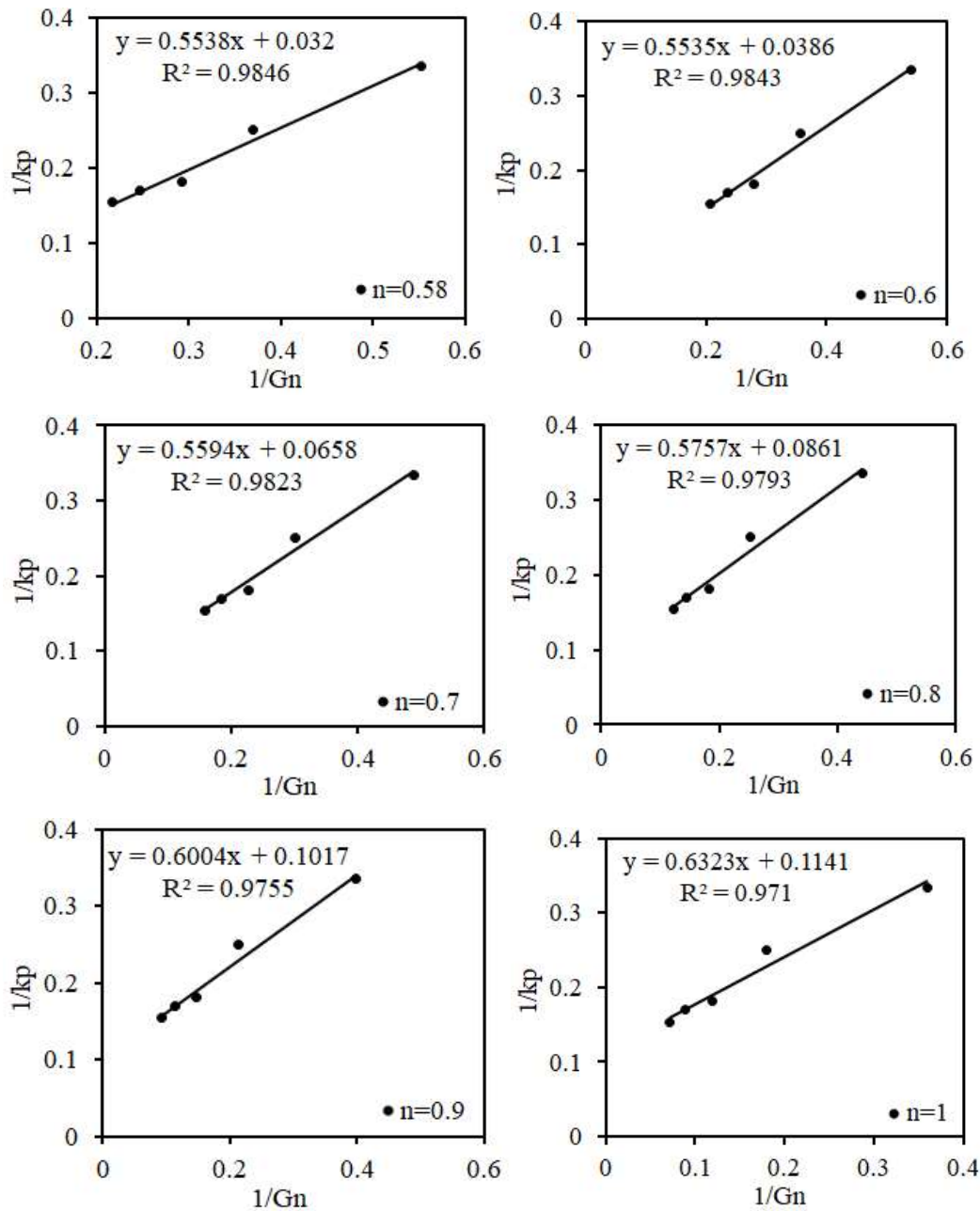


**Figure B-4.** Particle size distribution of low density polyethylene.

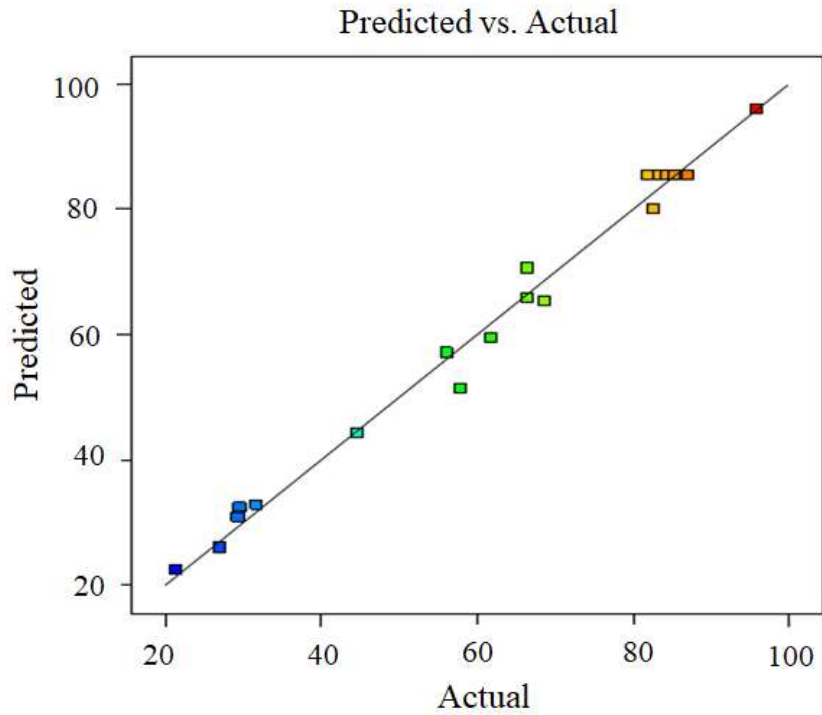


**Figure B-5.** Particle size distribution of polyurethane foam.

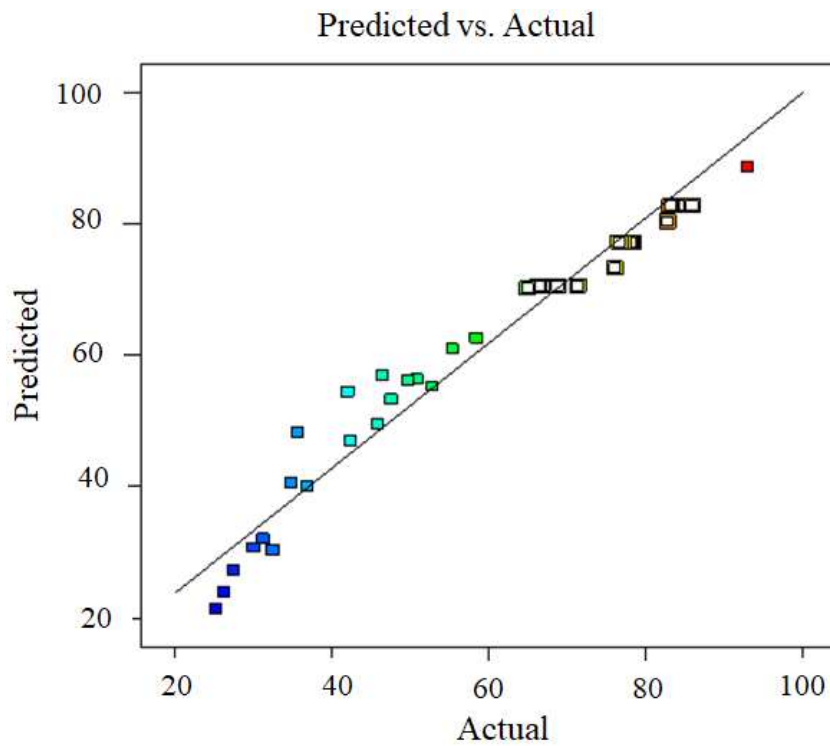




**Figure B-6.** The observed profile of  $1/kp$  vs.  $1/Gn$  at different  $n$  values obtained in PBBR study.



**Figure B-7.** Actual vs. predicted graph of naphthalene degradation study in AIPT.



**Figure B-8.** Actual vs. predicted graph of naphthalene degradation study in MBBR.

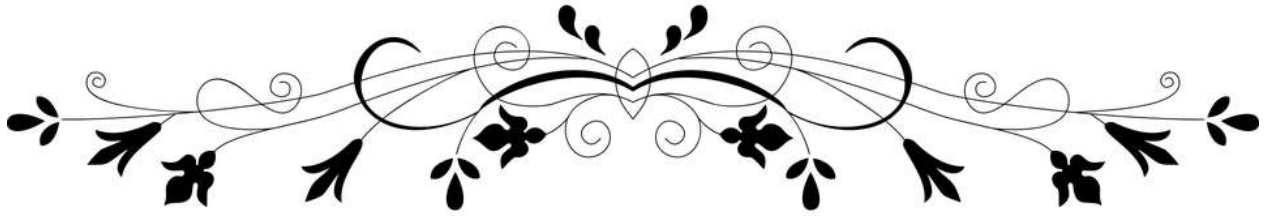
## Appendix C

**Table C-1.** Comparison of experimental and calculated values of  $k_p$  at various flow rates.

Q (mL/h)	$k_p$ (Experimental) (mL/g.h)	$k_p$ (Calculated) (mL/g.h)					
		n=0.5	n=0.6	n=0.7	n=0.8	n=0.9	n=1.0
20	2.99	2.986	2.986	2.984	2.982	2.988	2.988
40	4.02	4.077	4.078	4.099	4.098	4.097	4.088
60	5.51	5.488	5.502	5.501	5.505	5.502	5.502
80	5.90	5.873	5.897	5.898	5.899	5.883	5.983
100	6.49	6.474	6.492	6.494	6.497	6.499	6.498

**Table C-2.** Profile of intermediates identified using GC-MS.

Compound/ metabolites	Molecular formulae	Molecular Weight	Retention time (min)	m/z of fragments ion (% relative abundance)
Naphthalene	C <sub>10</sub> H <sub>8</sub>	128	15.217	26,51,64,75,86,102,125,128
Catechol	C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>	110	15.621	13,27,39,53,64,81,92,110,112
2-Naphthol	C <sub>10</sub> H <sub>8</sub> O	144	24.51	28,39,51,63,72,89,98,115,126,144



***LIST OF RESEARCH PUBLICATIONS***

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## List of publications (First author)

- ❖ R. K. Sonwani, G. Swain, R. P. Jaiswal, R. S. Singh, B. N. Rai, 2021. Moving bed biofilm reactor with immobilized low-density polyethylene–polypropylene for Congo red dye removal. *Environmental Technology & Innovation*. (Accepted on April 12, 2021; <https://doi.org/10.1016/j.eti.2021.101558>).
- ❖ **R. K. Sonwani**, G. Swain, B. S. Giri, R. S. Singh, B. N. Rai, 2020. Biodegradation of Congo red dye in a moving bed biofilm reactor: Performance evaluation and kinetic modeling. *Bioresource Technology*, 302, 122811.
- ❖ **R. K. Sonwani**, B. S. Giri, Ravi P. Jaiswal, R. S. Singh, B. N. Rai, 2020. Performance evaluation of a continuous packed bed bioreactor: Bio-kinetics and external mass transfer study. *Ecotoxicology and Environment Safety*, 201, 110860.
- ❖ **R. K. Sonwani**, G. Swain, R.S. Singh, B. N. Rai, 2020. Optimization of Methylene blue removal by mixed bacterial culture isolated from dye contaminated site. *Journal of Indian chemical Society*, 97, 345-350.
- ❖ **R. K. Sonwani**, B.S. Giri, R.S. Singh, B. N. Rai, 2019. Studies on optimization of naphthalene biodegradation using surface response methodology: kinetic study and performance evaluation of a pilot scale integrated aerobic treatment plant. *Process Safety and Environmental Protection*, 132, 240-248.
- ❖ **R. K. Sonwani**, G. Swain, B.S. Giri, R.S. Singh, B. N. Rai, 2019. A novel comparative study of modified carriers in moving bed biofilm reactor for the treatment of wastewater: Process optimization and kinetic study. *Bioresource Technology*, 281, 335-342.
- ❖ **R. K. Sonwani**, B. S. Giri, T. Das, R. S. Singh, B. N. Rai, 2019. Biodegradation of fluorene by neoteric LDPE immobilized *Pseudomonas pseudoalcaligenes* NRSS3 in a packed bed bioreactor and analysis of external mass transfer correlation. *Process Biochemistry*, 77, 106-112.
- ❖ **R.K. Sonwani**, B.S. Giri, S. Sabbarwal, R.S. Singh & B. N. Rai, 2019. Performance evaluation and kinetic study of fluorene biodegradation in continuous bioreactor using polyurethane foam as packing media. *Indian Journal of Experimental Biology*, 57, 870-878.

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## List of publications (Group)

- ❖ G. Swain, R.K. Sonwani, R.S. Singh, R. P. Jaiswal, B.N. Rai, 2021. Removal of 4-Chlorophenol by *Bacillus flexus* as free and immobilized system: Effect of process variables and kinetic study. Environmental Technology & Innovation, 21, 101356 (1-12).
- ❖ G. Swain , S. Singh , R.K. Sonwani , R.S. Singh , Ravi P. Jaiswal , B.N. Rai, 2021. Removal of Acid Orange 7 dye in a packed bed bioreactor: Process optimization using response surface methodology and kinetic study. Bioresource Technology Reports, 13, 100620 (1-10).
- ❖ G. Swain, **R. K. Sonwani**, B. S. Giri, R. S. Singh, Ravi P. Jaiswal, B. N. Rai, 2021. A study of external mass transfer effect on biodegradation of phenol using low-density polyethylene immobilized *Bacillus flexus* GS1 IIT (BHU) in a packed bed bioreactor. Water and Environment Journal, 35, 285-294.
- ❖ G. Swain, **R. K. Sonwani**, B. S. Giri, R. S. Singh, Ravi P. Jaiswal, B. N. Rai, 2020. Collective removal of phenol and ammonia in a moving bed biofilm reactor using modified bio-carriers: Process optimization and kinetic study, Bioresource Technology, 306, 123177.
- ❖ M. Goswami, P. Chaturvedi. **R. K. Sonwani**, A. D. Gupta, R. R. Singhania, B. S. Giri, B. N. Rai, H. Singh, S. Yadav, R. S. Singh, 2020. Application of Arjuna (*Terminalia arjuna*) seed biochar in hybrid treatment system for the bioremediation of Congo red dye. Bioresource Technology, 307, 123203.
- ❖ B. S. Giri\* , M. Goswami, P. Kumar, R. Yadav, N. Sharma, **R. K. Sonwani**, S. Yadav, R. P. Singh, E. R. Rene, P. Chaturvedi, R. S. Singh, 2020. Adsorption of patent blue V from textile industry wastewater using *Sterculia alata* fruit shell biochar: evaluation of efficiency and mechanisms. Water, 12, 1-16.
- ❖ G. Swain, **R. K. Sonwani**, P. Nagar, B. S. Giri, R. P. Jaiswal, R. S. Singh and B. N. Rai, 2020, Biodegradation and kinetic analysis of phenol using low-density polyethylene immobilized *Bacillus flexus* GS1 IIT (BHU) in a packed bed bioreactor. Journal of Indian chemical society, 97, 332-338.
- ❖ M. K. Verma , A. Kumar , T. Das , V. Kumar , S. Singh , V. S. Rai , D. Prajapati, **R. K. Sonwani**, K. Sahoo, K. D. Mandal, 2020. BiFeO<sub>3</sub> perovskite as an efficient photocatalyst synthesized by soft chemical route, Materials Today, Advance performance material, 1-10.
- ❖ Ganesh Swain, **R. K. Sonwani**, R. S. Singh, Ravi P. Jaiswal, B. N. Rai, 2020. Removal of Acid blue 113 dye in a moving bed biofilm reactor using isolated bacterial species. Journal of Indian Chemical Society, 97, 1-6.
- ❖ B. S. Giri, A. Sarowgi, Y. Kaushik, A. Pal, A. Jaiswal, S. Kumari, H. Singh, **R. K. Sonwani**, V. Thivaharan, R. S. Singh, 2019. Indoor potted plant based biofilter: Performance evaluation and kinetics study. Indian Journal of Experimental Biology, 57, 879-886.
- ❖ M. K. Verma, A. Kumar, L. Singh, **R. K. Sonwani**, T. Das, S. Singh, V. Kumar, N. B. Singh, K. Mandal\* (2019). Bi<sub>25</sub>FeO<sub>40</sub> polycrystalline ceramic as highly efficient photocatalyst synthesized via economical chemical route, Journal of Chemical Physics, 35, 483-493.

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- ❖ V. Bharti, K. Vikrant, M. Goswami, **R. K. Sonwani**, J Lee,. ... & B. N. Rai, 2019. Biodegradation of methylene blue dye in a batch and continuous mode using biochar as packing media. *Environmental Research*.171, 356-364.
  - ❖ K. Roy, K. Verma, K. Vikrant, M Goswami, **R. K. Sonwani**, B. N. Rai, K. Vellingiri, K-H Kim, B.S. Giri, Singh R.S., 2018. Removal of patent blue (V) dye using Indian bael shell biochar: Characterization, application and kinetic studies. *Sustainability* 10, 2669.

### List of conferences/Workshops

- **R. K. Sonwani**. Participated in the “International E-Conference on Frontiers in Industrial Biotechnology”, organized by the St. Joseph’s College of Engineering, Chennai, India (27 July, ICFIBT 2020).
- **R. K. Sonwani**, R. S. Singh, B. N. Rai. Removal of naphthalene in a moving bed biofilm reactor using isolated bacterial species. CHEM-CONFLUX2020, an International conference on Energy and Environmental Technologies for Sustainable Development MNNIT, Allahabad, India (14-16, February 2020) (**Oral presentation**).
- **R. K. Sonwani**, R. S. Singh, B. N. Rai. Development of new carriers in moving bed biofilm reactor for the wastewater treatment: Optimization and kinetic modelling. 12<sup>th</sup> National conference on Chemical and Environmental Science: Advanced Innovation (CESAI 2020), Punjabi University Patiala, India (19-20, February 2020) (**Oral presentation**).
- **R. K. Sonwani**, Balendu Shekhar Giri, Tapas Das, Ram Sharan Singh, Birendra Nath Rai, “Biodegradation of PAH by immobilized *Pseudomonas pseudoalcaligenes* NRSS3 in a packed bed bioreactor and analysis of external mass transfer correlation”, International conference on Bio-Innovation for environmental and health sustainable developments (BEHSD-2018), CSIR-IITR, Lucknow, India (27-28 Nov 2018).
- **R. K. Sonwani**, B. S. Giri, T. Das, R. S. Singh, B. N. Rai, “Performance evaluation of continuous packed bed bioreactor for the treatment of wastewater containing PAH by *Exiguobacterium* sp. RKS3 (MG696729) isolated from petroleum contaminated site”, International conference on sustainable water resources, innovations and impacts (TECHNOSCAPE-18), VIT Vellore, India (6-8 Sep 2018) (**Oral presentation**).
- **R. K. Sonwani**, B. S. Giri, S. R. Geed, R. S. Singh, B. N. Rai, Combination of UV–Fenton oxidation process with biological treatment of polycyclic aromatic hydrocarbons (naphthalene and fluorene) using isolated bacterial species from petroleum contaminated site”, International conference on ETBWC-2017, CSIR-NEERI, Nagpur India (8 -10, October 2017).
- Participated in a workshop on inclusion of smart city planning of India of renewable energy and efficiency (INSPIRE) held on 25<sup>th</sup> March, 2017 organised by IIT (BHU), Varanasi, India.