Grenze International Journal of Engineering and Technology, June Issue

Single-Stage RBC: A Sustainable Solution for Dairy Wastewater Treatment

Pallavi S. Chakole[1], Ajay R. Gajbhiye[2] and Praveen Kumar[3]
[1]Research Scholar & Assistant Professor, Civil Department Yeshwantrao Chavan College of Engineering, Nagpur, India
Email: chakole121pallu@gmail.com
[2]Civil Department Yeshwantrao Chavan College of Engineering, Nagpur, India
Email: yccehodcivil@yahoo.com
[3]Faculty of Engineering and Technology, Datta Meghe Institute of Higher Education & Research Wardha

***Abstract*— A biological treatment method called the Rotating Biological Contactor (RBC) employs fixed films that can be used as a component of the secondary treatment procedure. This study describes the use of a single stage rotating biological contactor (RBC) for the treatment of dairy effluent. This unit was fabricated as a lab scale unit for treating small quantity of dairy wastewater, to remove organic pollutants. Usually found on a similar horizontal shaft, an RBC unit is made up of several closely spaced huge flat or corrugated discs that are either fully or partially submerged in wastewater. A biofilm is created on the whole surface area of the media, which breaks down the organic materials in the wastewater, while the shaft is continuously rotated by a mechanical motor or a compressed air drive. These discs attract microorganisms, which then grow on them. Typically, the discs that are fixed to the surface of a rotating shaft are composed of plastic but in the present study it is made up of acrylic material. In this research, discs of RBC are covered with two different bio-film medium such as Raw jute and Scouring sheet. Based on a comparison of the findings for this investigation, it has been determined that Raw jut as a bio-media can give more efficiency of BOD and COD removal as compared to scouring sheet as a media for 72 hr. of hydraulic retention time and at 5rpm.**

***Index Terms*— Biological treatment, Dairy wastewater, Rotating Biological Contractor, Attached growth, Suspended growth.**

I. INTRODUCTION

The challenge of sanitation in developing nations is exacerbated by rising water usage that coincides with population density. Untreated wastewater from homes and businesses being dumped into drainage systems is seen as a source of pollution endangering the public.[1] The environmental issues in developing nations are caused by poverty, socioeconomic factors, and illiteracy in addition to industrial wealth. Organic contaminants should be taken into consideration as one of the fundamental issues.[2] India has seen the emergence of numerous agro-based companies in recent years. One such industry that has grown significantly over the past two decades because of the massive growth in milk output is the milk processing sector. To ensure that milk is handled and processed efficiently, there are now more medium- and large-sized dairy factories. The creation of wastewater has also increased as a result of the increased production of milk and its processing. It has been estimated that the Indian dairy sector produces 6–10 liters of wastewater for every liter of processed milk. [3] [4]

Grenze ID: 01.GIJET.11.2.212_20

Industrialization has a significant impact on the nation's science and economics. Industries typically produce a lot of wastewater as a result of their operational procedures.[5] India is one of the world's major producers of milk and dairy products; in 2002, its annual milk output surpassed 85 million tonnes, and it is currently expanding at a pace of 2.8% annually. [6] As the demand for different dairy products rises, the dairy sector produces a lot of waste because of its operational procedures. Oil, grease, protein, lipids, and both organic and inorganic materials are present in dairy waste. [7] The majority of agro-industries, including the dairy sector, produce enormous amounts of wastewater, which are distinguished by elevated levels of biological oxygen demand (BOD) and chemical oxygen demand (COD), both of which are markers of their high organic content.[8]

Organic and biodegradable materials that can interact with aquatic and other terrestrial habitats are generally present in dairy waste. The high pollutant load of dairy wastewater makes it a major environmental concern for the milk and other milk-related processing businesses that release untreated or poorly treated wastewater. [9] Hence, more advancements in wastewater treatment technologies are required to meet stricter environmental standards. This will not only ensure that they meet regulations and have a low energy footprint, but also improve their economic viability and environmental sustainability.[10] In order to eliminate biodegradable organics and, to a lesser degree, nutrients from wastewater, aerobic biological processes have been considered as efficient treatment techniques. These growth procedures can be roughly categorized into two groups based on microbial development: suspended (activated sludge) and attached (trickling filter, revolving biological contactors). [11] There are benefits and drawbacks to both attached and suspended growth systems. Although suspended growth is more effective at removing organic materials and some pollutants, it needs more energy and upkeep to keep the system stable. Though more prone to clogging and requiring more frequent maintenance, attached growth is more effective at eliminating some contaminants. The kind and concentration of pollutants, the amount of space and resources available, and the intended level of treatment efficacy and efficiency all influence the decision between suspended-growth and attached-growth systems.[12][13]

A. Overview of RBC

The first rotating biological contactor (RBC) was created in Germany in the early 1920s and was initially defined as a mass of revolving aerobic fixed attached to a medium support. The first one, known as the biological wheel or contact filter at times, was implemented on a plant scale in the United States. RBC systems have been used historically to treat wastewater and remove organic carbon. Later, this procedure was expanded to incorporate the nitrification and denitrification of wastewater.[14] [15] An alternate technique to the traditional activated sludge process is a growth bioreactor called a rotating biological contactor (RBC). [16] Wastewater from industrial and domestic is typically treated using this technique as a secondary treatment. The breakdown of organic materials in a spinning biological contactor is caused by disc biomass. Rotating biological contactors are made up of a number of circular disks of polymer materials, such as acrylic plastic, polystyrene, polyvinyl chloride, and polyethylene, and a glass container of varying sizes known as a reactor. These disks are circulated through wastewater while submerged in it. The discs are fixed to a horizontal shaft and turned by an electric motor with variable speed. RBC might be single-stage or multistage. The performance of RBCs is influenced by numerous factors, including biomass, hydraulic capacity, loading rate, peripheral speed, wastewater thermal conditions, and medium submergence.[17][18] RBCs can be used in a variety of ways because of their exceptional ability to extract nutrients and organic materials from wastewater. RBCs are an economical choice for wastewater treatment since they consume little energy. The purpose of this study was to look into a straightforward, inexpensive, single-stage RBC system for the treatment of highly concentrated effluent from dairy products and efficiency of an RBC unit can be assessed by evaluating wastewater BOD, COD, TSS, pH and other characteristics before and after treatment and main findings is removal efficiency of BOD and COD.

II. MATERIALS AND METHODS

A. Wastewater

The dairy waste water used in this study was obtained from “Dinshaw Factory” (Nagpur). Dinshaw industry exhales 5000 litres of wastewater. So, the industry was selected as Dinshaw. Because of the high COD concentration, a noteworthy feature of the collected effluent, the treated water is unfit for human consumption.

B. Fabrication of Rotating Biological Contactor

In order to create an RBC reactor, 14 discs composed of acrylic sheets were used. Two discs were separated by 2.5 cm, and each disk had a diameter of 22 cm and a thickness of 10 mm. Because the disc was made of acrylic,

its smooth surface area was roughened by scratching it with a knife on both sides in a vertical and horizontal direction to encourage the attachment and proliferation of microorganisms. An electric motor with a fixed power input geared the discs, which were attached on a shaft, to rotate at a fixed speed of 5 rpm.A motor having 5 kg torque was connected at one end with the control panel and a rpm controller. The shaft traveled through the middle of each disc and was fixed to the bearings that were fastened to the wastewater container's ends. The discs were 43 percent submerged. There were 35 illuminated in the trough.

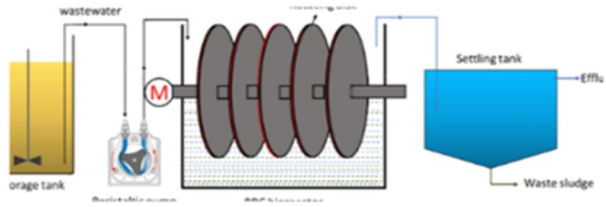


Figure 1. Design Layout of an RBC System

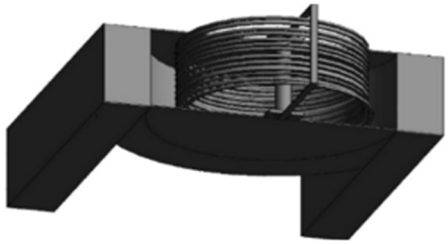


Figure 3. Actual Design setup of Rotating Biological Contactor

C. Operational Mechanism of an RBC System:

The reactor operates via the associated growth system's mechanism. The media profile has been used to wrap the disk up. The shaft-mounted disc remained 43 percent submerged during the trial, and the disc's rotation with the media profile was maintained at 5 rpm. Two pulleys and a single-phase motor were used to accomplish the rotation.

TABLE I. PROPERTIES OF REACTOR

Specification	**Values**
Number of stages	1
Total Discs	14
Diameter of the Disc (cm)	22
Distance Between Discs (cm)	2.5
Working volume of the reactor	30 litre
Disc Thickness(mm)	10
Submergence (%)	43
Rotations Per Minute	5

D. Properties of Medias

- Tag [raw jute]: Tag [raw jute] is used as a material or media in many different contexts, particularly in wastewater treatment or other industrial applications, because of its natural qualities. In wastewater treatment, Tag [raw jute] is used as a media in treatment systems such as Rotary Biological Contactors (RBCs), where its fibrous structure offers a perfect surface for microorganisms to grow and attach, it aids in the wastewater's organic contaminants' breakdown. The goal of using raw jute in these systems is to increase treatment effectiveness while providing a more economical and ecologically friendly substitute for synthetic materials.
- Scouring sheets: The effectiveness of wastewater treatment is increased when scouring sheets are used in rotating biological contactors (RBCs). Because of its long-lasting and abrasive qualities, scouring sheets efficiently remove impurities and biofilm from the surfaces of RBC medium. They are perfect for ongoing usage in wastewater treatment systems because of their adaptability and chemical tolerance. All things considered, scouring sheets enhance RBC performance and provide an affordable, low-maintenance option for producing clean water.

III. RESULTS AND DISCUSSION

BOD and COD performance efficiency by application of RBC was studied in the laboratory. Samples were taken for both untreated and treated wastewater.

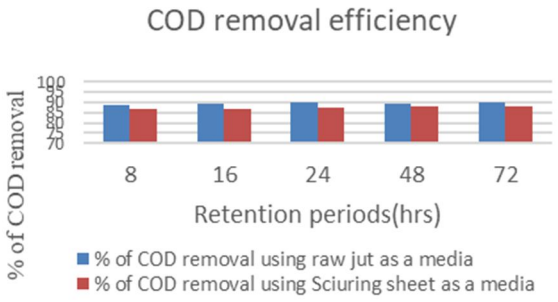
Samples were collected after retention periods of 8, 16, 24 ,48 and 72 hours and studied in the lab to determine how effectively BOD and COD were removed by using raw jute and scouring sheet as a media. These results were shown in Table 3 and 4. Along with efficiency of the RBC attained in each situation based on detention time and compare the results of medias that which is giving more BOD and COD removal efficiency.

TABLE. II COD REMOVAL EFFICIENCY FOR 72 HOUR'S DETENTION TIME

For untreated sample COD (mg/lit)	For treated sample using raw jut as a media COD (mg/l)	% of COD removal	Overall COD removal % using raw jut	For treated sample using scouring sheets as a media COD (mg/l)	% of COD removal	Overall COD removal % using scouring sheets
5240	580	88.93	89.57	680	87.02	87.45
5120	540	89.45		666	86.99	
5100	510	90		635	87.54	
5000	520	89.6		610	87.8	
4940	498	89.91		596	87.93	

TABLE. III BOD REMOVAL EFFICIENCY FOR 72 HOUR'S DETENTION TIME

For untreated sample BOD (mg/lit)	For treated sample using raw jut as a media BOD (mg/l)	% of BOD removal	Overall BOD removal % using raw jut	For treated sample using scouring sheets as a media BOD (mg/l)	% of BOD removal	Overall BOD removal % using scouring sheets
1500	315	79	80.01	520	65.33	66.29
1460	300	79.45		505	65.41	
1480	292	80.27		493	66.68	
1420	285	79.92		470	66.90	
1400	260	81.42		460	67.14	



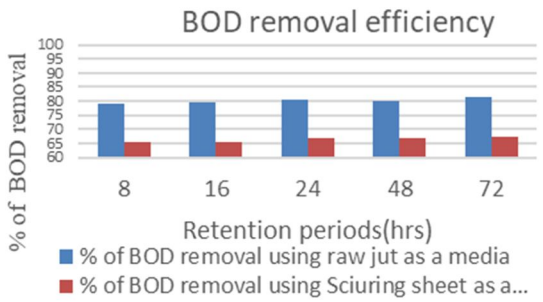


Figure 6. COD removal efficiency using Raw jute and scouring sheets Figure 7. BOD removal efficiency using Raw jute and scouring sheets

The recorded values in Table no II. confirm that RBC can effectively reduce COD after a 72 hours of detention period. With total efficiency of COD removal is 89.57 by raw jut as media and 87.45 using scouring sheet as a media. However, from table no III. It is observed that there is considerable reduction of BOD with increased in detention period up to 72 hrs. i.e. average efficiency of about 80.01 using raw jut as media and 66.29 using scouring sheet as a media.

Both above-mentioned findings demonstrate that RBC can be used successfully as secondary treatment to lower the cost of treating patients with high BOD and COD level by using low-cost medias. Since dairy wastewater has high BOD and COD, it requires an efficient treatment like RBC.

IV. CONCLUSION

The wastewater treatment industry has made extensive use of RBCs because of their great efficacy of treatment, cheap operating costs, and simplicity of usage. Furthermore, RBCs may be essential to attaining environmentally sound performance over the long term. RBCs reduce the detrimental effects of wastewater on water quality by efficiently treating wastewater and eliminating contaminants such organic matter, BOD, COD, another parameter also before releasing them into the environment.

Based on the results of the current study, it has been determined that raw jut as a bio-media is more effective at removing COD than scouring sheets as a media. Similarly, raw jut as a bio-media is more effective at removing BOD than scouring sheets as a media.

The maximum removal efficiency is achieved during the 72-hour retention period. As the collected wastewater is Dairy wastewater the main concern is BOD and COD. The percentage reduction in above two parameter is carried out with increase in HRT and it was observed that its efficiency is much reduced.

Hence, these treatments conclude that the dairy wastewater treated by raw jute and scouring sheet on RBC unit for 72 hrs. has nearly satisfactory value. But by comparing these two medias Raw jute give more percentage removal efficiency as compared to scouring sheet at 5 rpm.

ACKNOWLEDGMENT

I sincerely to extent my thanks to my PhD supervisor for his guidance and support for the research and my colleagues, unique task done by technical personnel, and financial assistance from institutions for all support and encouragement in all my difficult pathways throughout the research.

REFERENCES

[1] A. Tawfik, H. Temmink, G. Zeeman, and B. Klapwijk, "Sewage treatment in a Rotating Biological Contactor (RBC) system," Water Air Soil Pollut, vol. 175, no. 1–4, pp. 275–289, Sep. 2006, doi: 10.1007/s11270-006-9138-6.
[2] B. Zaman, E. Sutrisno, F. P. Cahyani, and D. M. Raharyani, "Banana Tree as Natural Biofilter for Organic Contaminant in Wastewater Treatment," in IOP Conference Series: Earth and Environmental Science, Institute of Physics Publishing, Apr. 2020. doi: 10.1088/1755-1315/448/1/012031.
[3] P. A. Kadu, R. B. Landge, and Y. R. M. Rao, "Treatment of dairy wastewater using rotating biological contactors," 2013. [Online]. Available: www.pelagiaresearchlibrary.com
[4] K. K. Modi and K. krishnakumar Nath, "Modification and Performance of a Rotating Biological Contactor for the Rectification of Synthetic Auramine O dye Wastewater," Current World Environment, vol. 18, no. 3, pp. 1098–1112, Jan. 2024, doi: 10.12944/cwe.18.3.15.
[5] L. Subhadarsini and R. Roshan Dash, "Treatment of Industrial Waste Water using Single-Stage Rotating Biological Contactor," in IOP Conference Series: Materials Science and Engineering, IOP Publishing Ltd, Nov. 2020. doi: 10.1088/1757-899X/970/1/012025.
[6] S. Murugesan Wood, "Performance study on Rotating Biological Contactor", doi: 10.13140/RG.2.2.25602.17607.
[7] S. N. S and S. B. Thakare, "Modified Rotary Biological Contactor using Bio-Media in Dairy Wastewater Treatment," 2019, doi: 10.15680/IJIRSET.2019.0807027.
[8] A. Ebrahimi, M. Asadi, and G. D. Najafpour, "DAIRY WASTEWATER TREATMENT USING THREE-STAGE ROTATING BIOLOGICAL CONTACTOR (NRBC)," 2009. [Online]. Available: www.SID.ir
[9] P. Powar, V. Nejkar, P. Patil, and V. Naik, "Dairy Wastewater Treatment with Rotating Biological Contactor as Secondary unit and use of Treated Effluent for Agriculture," in E3S Web of Conferences, EDP Sciences, Jul. 2023. doi: 10.1051/e3sconf/202340501006.
[10] S. Waqas et al., "An energy-efficient membrane rotating biological contactor for wastewater treatment," J Clean Prod, vol. 282, Feb. 2021, doi: 10.1016/j.jclepro.2020.124544.
[11] P. Saikaly and G. M. Ayoub, "AMMONIA NITROGEN REMOVAL IN STEP-FEED ROTATING BIOLOGICAL CONTACTORS," 2003.
[12] S. Waqas et al., "A Review of Rotating Biological Contactors for Wastewater Treatment," May 01, 2023, MDPI. doi: 10.3390/w15101913.
[13] G. D. Najafpour, A. A. L. Zinatizadeh, and L. K. Lee, "Performance of a three-stage aerobic RBC reactor in food canning wastewater treatment," Biochem Eng J, vol. 30, no. 3, pp. 297–302, Jun. 2006, doi: 10.1016/j.bej.2006.05.013.
[14] R. M. Elhefny, H. A. Fouad, and M. A. Mohamed, "Reviewing Rotating Biological Contactor's Different Aspects for Wastewater Treatment with Experiment," 2022.
[15] I. Vinage and P. R. Von Rohr, "Biological waste gas treatment with a modified rotating biological contactor. II. Effect of operating parameters on process performance and mathematical modeling," Bioprocess Biosyst Eng, vol. 26, no. 1, pp. 75–82, Nov. 2003, doi: 10.1007/s00449-003-0333-1.
[16] M. R. Tonde, S. B. Patil, and J. R. Mali, "International Journal of Current Engineering and Technology Review Paper on Study of Rotating Biological Contactor for Wastewater Treatment Process," 2015. [Online]. Available: http://inpressco.com/category/ijcet
[17] S. Rana, N. Gupta, and R. S. Rana, "Removal of Organic pollutant with the use of Rotating Biological Contactor," in Materials Today: Proceedings, Elsevier Ltd, 2018, pp. 4218–4224. doi: 10.1016/j.matpr.2017.11.685.
[18] Kiruthika A, Kiruthika,] Anupriyar, Elamaran, and Manogodson, "TREATMENT OF DAIRY WASTEWATER USING ROTATING BIOLOGICAL CONTACTOR," International Journal of Advanced Information Science and Technology (IJAIST) ISSN, vol. 6, no. 8, 2017, doi: 10.15693/ijaist/2017.v6i8.1-4.