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Treatment of Synthetic Leachate by Rotating Biological Contactor: A Review

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Abstract: ***Disposal of leachate into the environment is quite problematic due to its extent of contamination, so leachate should be treated and disposed of safely to safeguard the environment. There exist many treatment techniques for treating the leachate but RBC systems are quite popular among those techniques because of its simplicity maintenance low economical factor and relatively less area requirement. Based on the below literature studies it is observed that RBC systems are efficient in the removal of organic and inorganic constituents.***

Leachate treatment must be done because even after the contamination of the environment, traces of the pollutants still exists [1]. The removal efficiency of pollutants depends on the MLSS concentration; at high MLSS concentration removal efficiency was high but with some negative effects because settling characteristics of sludge will be low at higher MLSS concentration [4]. Various parameters like RPM, temperature, wastewater characteristics, dissolved oxygen, submergence of discs, organic loading rate, media, and hydraulic loading rates can influence the performance of RBC [5].

The continuous flow rate of wastewater in the RBC can facilitate more removal efficiencies of pollutant constituents. Optimum submergence of 40% - 42% recommended for treating leachate. High ambient temperature can cause an increase in removal efficiency [6].

RBC with modified design considerations even also can capable to achieve the treatment of leachate [7]. Under various nutrients and hydraulic loading rates, RBC can sustain easily and most of the performance from RBC depends upon the operating configuration and temperature [8]. Based on various characteristics and design considerations, the removal efficiency of BOD and COD ranges up to 90%.

I. INTRODUCTION

Groundwater is the primary source and major natural source of potable water in many areas, due to overpopulation, urbanization, and industrialization in modern days, most of the groundwater aquifers tend to get contaminated especially in developed countries like India.

The quality of groundwater depends upon various causes like geology, location type, and quantity of dissolved ions present in it[16].In many areas groundwater prone to contamination by various reasons and one of the major reasons that cause groundwater contamination is land filling and most importantly due to contamination by highly toxic landfill leachate.

Landfill leachate contains highly organic and inorganic complex compositions, ammonia and nitrogen salts, heavy metals and toxic chemicals [2].

Sometimes due to contamination of soil with leachate' dissolved and suspended materials, the soil remains contaminated even the dumping of waste ceased in the landfill. By this phenomenon, agriculture will get affected due to the consumption of leachate toxic material by plants in their tissue [17].

Due to its nature, Leachate must be treated with an appropriate measure. Biological treatment is the most effective and efficient treatment method to reduce the toxicity of leachate. There are various types of biological methods that exist and the proper treatment method selected, based on the characteristics of wastewater, nature of treatment and treatment operation.

Rotating biological contactors are the most efficient fixed-film wastewater treatment technologies used to treat strong leachates.

RBC systems were well suited for secondary or advanced treatment in municipal and industrial applications. The process consists of large diameter corrugated plastic media centered around a horizontal shaft, mounted in a steel or concrete tank. The media is slowly rotated, submerged 40% in the wastewater.

Bacteria in the wastewater accumulates and attach to the rotating media and multiplies until thin biofilm forms on the discs. Oxygen in the atmosphere dissolves and diffuses into the leachate and metabolizes the bacterial growth which removes the pollutants in the leachate. Most of the authors stated

II. LITERATURE REVIEW

E. Gaitanelis(2012) “Study of the Environmental Impacts of Uncontrolled Landfill Leachate Disposal to the Surrounding Environment" In this paper, they investigated solid waste management in Greece. It was a case study in which the leachate is escaped from the storage tank. To investigate the extent of the pollution caused by the leachate's escape they took samples from various locations near the vicinity of the landfill. By evaluating the results of the experiments, they found there was contamination occurrence near the landfill vicinity. They conducted tests for several months and realized contamination of through the landfill persists 8 moths and the escaped untreated leachate continues to exist for that long time. They concluded existing reverse osmosis plant near the landfill is for the treatment of leachate is not enough because it may prone to failure and having heavy operating costs. So they recommended pre-treatment of leachate. [1]

Li Rong (2009) “Management of Landfill leachate" Characterized the landfill leachate, He characterized leachate based on various parameters like color and smell, pH, BOD, COD, TOC, TDS, Suspended solids, salts, and heavy metals. He provided concentrations of various parameters and their ranges. The range of pH is 4~9, COD ranges of 2000 to 62000 mg/L, BOD concentration ranges of 60 to 45000 mg/L, Color and Smell is Orange-Brown and malodorous smell,the concentration of TOC is ranging from 265 to 2800 mg/L, Total dissolved solids range up to 10000mg/L, 3~10 of suspended solids and 100~4000mg/L of chlorides. Heavy metals include Cu, Zn, Pb, Cd, Hg, etc. He stated the treatment of leachate by anaerobic methods conserve more energy than the aerobic method, but the organic content in the leachate is degraded much more effectively than anaerobic treatment in aerobic methods. He conducted experiments for effective leachate treatment methods and designed constructed wetlands to improve treatment efficiency. [2]

Tapan Narayana (2008) "Municipal solid waste management in India" compared three methods of disposing of solid waste such as composting, landfilling and incineration. All three methods having their flaws. Generation of leachate mainly based on the rainfall and permeability of the liner in the landfill. To minimize the problem modern landfills are constructed with an impermeable liner, regardless of the nature of liner, it eventually fails to contain leachate. This cause contamination of groundwater resource with various toxic substances like dioxins, PCBs and heavy metals. [3]

Saraswati Rana, Nitish Gupta and R.S Rana (2017) "Removal of organic pollutants with rotating biological contactor" They stated the removal efficiency of phenol in wastewater and the parameters like HRT, RPM, submergence of discs, the concentration of Mixed liquid suspended solids that affect the removal of pollutant. They fabricated the laboratory scale RBC reactor. They aerated the influent sludge for better oxygen transfer and increasing the overall organic consumption rates. They operated the RBC with various RPM from 5 to 50 and said that higher RPM facilitates the higher oxygen transfer based on the wastewater constituents. Disc submergence is another factor that influences the removal efficiency. For optimal removal efficiency, 40%-45% of disc submergence is recommended. They also stated MLSS concentration should be maintained at an optimum concentration that a very higher MLSS concentration has further negative impacts on the treatment of wastewater by RBC. [4]

S. Cortez, P. Teixeira, R. Oliveira, M. Mota (2008) discussed the “Main Factors That Affect The Performance Of RBC”. Organic and hydraulic loading rates, temperature, influent wastewater characteristics, medium submergence are some of the parameters that have been discussed in the paper. They said RBC can perform treatment facility for various wastewater pollutants like sugar refinery effluents, bioremediation of landfill leachate, treatment of effluent from wineries. They said higher rotational speeds can increase the oxygen transfer but decreases the biodegradation rate. As the applied organic loading rate increases, the substrate removal rate increases and removal efficiency decreases. They said, when the wastewater contains enough nutrients, the removal efficiency will be higher and some parameter values will get changed on specific conditions. Temperature is another parameter that influences the RBC's performance and it is maintained above 13°C for better removal of organics. [5]

Prashant A. Kadu (2012) “A Review of Rotating Biological Contactors System" He reviewed rotating biological contactors and the biofilm. He adopted RBC continuously and arranged several large flat and corrugated discs with the biofilm that submerged partially in the wastewater which provides easy oxygen transfer to the wastewater from the atmosphere. This paper stated various factors that influence the removal efficiency of the organic material in the wastewater like influent wastewater characteristics, hydraulic loading rate, organic loading rate specific surface of the discs, disc submergence, number of stages, ambient and wastewater temperature and shaft arrangement. He stated submergence level of 40%-42% is optimum for better removal efficiency. Temperature rise can increase the removal efficiency of the RBC system. [6]

M.L. Gulhane, S.V Sahare (2014) “Modified Rotating Biological Contactor” studied rotating biological contactor with the modified conventional circular discs with paddles/boxes that are made from plastic as a microbial growth media. These paddles facilitate the oxygen transfer from the atmospheric air and provide sufficient nutrients to the organism while submergence and increasing the metabolism of the bacteria. The organic compounds in the wastewater provide growth of bacteria and serve as a nutrient source for

metabolism. Different shafts, submergence levels of paddles and various RPMs are maintained throughout the study and various parameters like BOD, COD, pH, TS, TSS, and TDS are taken into consideration to decide the feasibility of the treating wastewater by RBC. By this study, they concluded a removal efficiency of BOD and COD are above 70%. [7]

Mr. K. Stalin (2014) "Performance of Rotating Biological Contactor in Wastewater Treatment "This paper focuses on the various parameters that influence the performance of RBC. He studied various papers regarding the performance of the RBC and concluded that the RBC systems with aerobic methods don't require any external aeration unit for oxygen transfer. RBC systems can withstand organic shock loads unlike activated sludge processing units and trickling filters and RBC units don't even need secondary sludge recirculation. The author stated the removal efficiency of RBC systems is efficient and the end products are non-toxic. [8]

E. Castillo M. Vergara (2006) researched the technical and operational feasibility of the rotating biological contactor for aerobic method and upward flow sludge blanket reactor in a bench-scale model for anaerobic method. They obtained optimum COD removal of 69% and 74% using perforated acetate discs as a growth medium with 40%-disc submergence. Optimum removal rates of COD observed at high HRT and they were not recommended high HRTs because higher HRTs can consider possible fluctuations of load and leachate flow. They also stated sometimes, excessive growth of biomass on the medium happens due to entrapment and accumulation of inert material that doesn't contribute to degradation. [9]

Martin K Jaison, Meharban K H(2017) “Performance Analysis of Rotating Biological Contactor with Polypropylene and wool media” Analysed Rotating biological contactor having disc media composed of polypropylene and wool that withhold bacteria. They decided to conduct the batch experiments with a detention time of 3 days. Wastewater is treated with having COD concentration of 500-2000 mg/L. Max removal efficiency of COD was 76.7% observed throughout 4 batch experiments. Theystudied, while COD concentrations are high in the initial experiment, the removal efficiency was decreased and it always depends on the food/microorganism ratios in the wastewater. In course of time progression, TSS values are increased because of the sloughing of biofilm. [10]

A. Ebrahimi (2018) “Optimization of Whey Treatment in Rotating Biological Contactor: Application of Taguchi Method" experimented with treating whey using rotating biological contactor.16 PVC discs have been used with 3 stage compartment with RPM of 4 and 10 in the experiment. He observed a total of 92% COD removal with optimum parameters. He also investigated RBC with the second optimum condition to evaluate the performance. To evaluate the biomass weight quantified by upon flashing the biomass off from the meshed material by water, and filtered with 0.45 µm membrane filter and dried it for 24 hours with a temperature of 105 ºC.[11]

Abhay Srivastava(2018) “Performance evaluation of greywater treatment using Rotating Biological Contactor (RBC) along with Phytotreatment and future scope for use as drinking water" studied the performance of rotating biological contactor with 40% submergence in treatment of greywater. Greywater constitutes low organic content free from pathogens and also free from fecal matter. He conducted tests for BOD removal by RBC with an efficiency of 93%-36% and TSS removal with 84%-95% efficiency, along with these he conducted Phytotreatment. Treatment of the greywater includes the RBC system fallowed by the settling tank and disinfection unit. The below chart shows the percentage of removal of each specific parameter of grey water in three different seasons. The effluent from the RBC needs disinfection to reach drinking standards. [12]

Sr. No.	Parameters	Percentage removal of parameter		
		Winter	Spring	Summer
1	Total Hardness	60.5	49.3	56.2
2	COD	90.8	82.1	89
3	TDS	80	71.9	81.2
4	TSS	89.9	85.3	89.2
5	Oil and grease	97	95	97
6	Fluorine	52.9	48.8	51.3
7	Chlorine	49	45.4	47.6
8	Nitrites	99.9	96	99.9
9	Nitrates	74.8	67.9	71.6
10	Phosphates	99.9	92	99.8
11	Sulphates	80.2	48.7	71.3
12	Sodium	72.2	51.7	69.1
13	Potassium	70.3	59.4	62.5
14	Magnesium	100	98.1	100
15	Nitrogen	82.8	76.1	83.5
16	Calcium	100	91.2	98.5

Fig.1. Percentage removal parameters

Manoj R. Tonde (2017) "Study of Rotating Biological Contactors (RBCs) for Wastewater Treatment Process" studied various parameters that influence the performance of rotating biological contactor systems. He experimented at various detention times such as 8 hrs, 12 hrs, 16 hrs, 24 hrs, 28 hrs, and 36 hrs. The maximum removal efficiency of BOD and COD observed at 36 hrs with 60% and 65% respectively. Regarding RPM 2, 3, 5, 7 has maintained and maximum removal of BOD and COD observed at RPM 2 with 75% and 70% respectively. He stated optimum RPM is 2 thatmaintained to remove BOD and COD.[13]

RongjunSu (2015) "Treatment of Antibiotic Pharmaceutical Wastewater Using a Rotating Biological Contactor" investigated RBC can be used to treat antibiotic pharmaceutical wastewater. In the paper, they stated low ambient temperatures can reduce the removal efficiency of COD and they achieved 85% removal efficiency in BOD removal in this investigation of RBC systems. They maintained COD concentrations of 400, 600, 800, 1000, 1200, 1400mg/L respectively and they found maximum removal efficiency at 400-800mg/L. This phenomenon due to organic input concentration and bacteria interaction. As for BOD, as the input concentration of wastewater Increases, BOD removal efficiency is decreased. In their investigation, they found that influent concentration and ambient temperatures are affecting the performance of RBC. [14]

Aditya Kamath (2018) "Treatment of Dairy Effluent using Rotating Biological Contactors" suggested RBC systems to minimize the treatment cost, which involves the attached growth method. Effluent from the study dairy industry constitutes 250 mg/l of BOD and 781.57 mg/l of COD. Provided RBC with 50% submergence and 6 RPM. They recommended Rotating biological contactors for an effective method of treating dairy wastewater and stated alternate to activated sludge process because of its maintenance, start-up, operation, high process stability with less space requirement. When RBC systems are adopted for treating wastewater, no territory removal is required. [15]

III. CONCLUSION

Treating landfill leachate by RBC is economical, easy to maintain, less area is required for treating unit and organic removal efficiencies are high. RBC is a unique treatment method and can effectively treat leachates having high BOD and COD concentrations. Alterations in the design and parameters can further increase the removal of pollutant constituents. It can easily withstand high organic load fluctuations. RBC systems can offer an alternative to ASP systems with relatively easy maintenance and less space requirement. It will conserve much energy as compared to activated sludge processing units.

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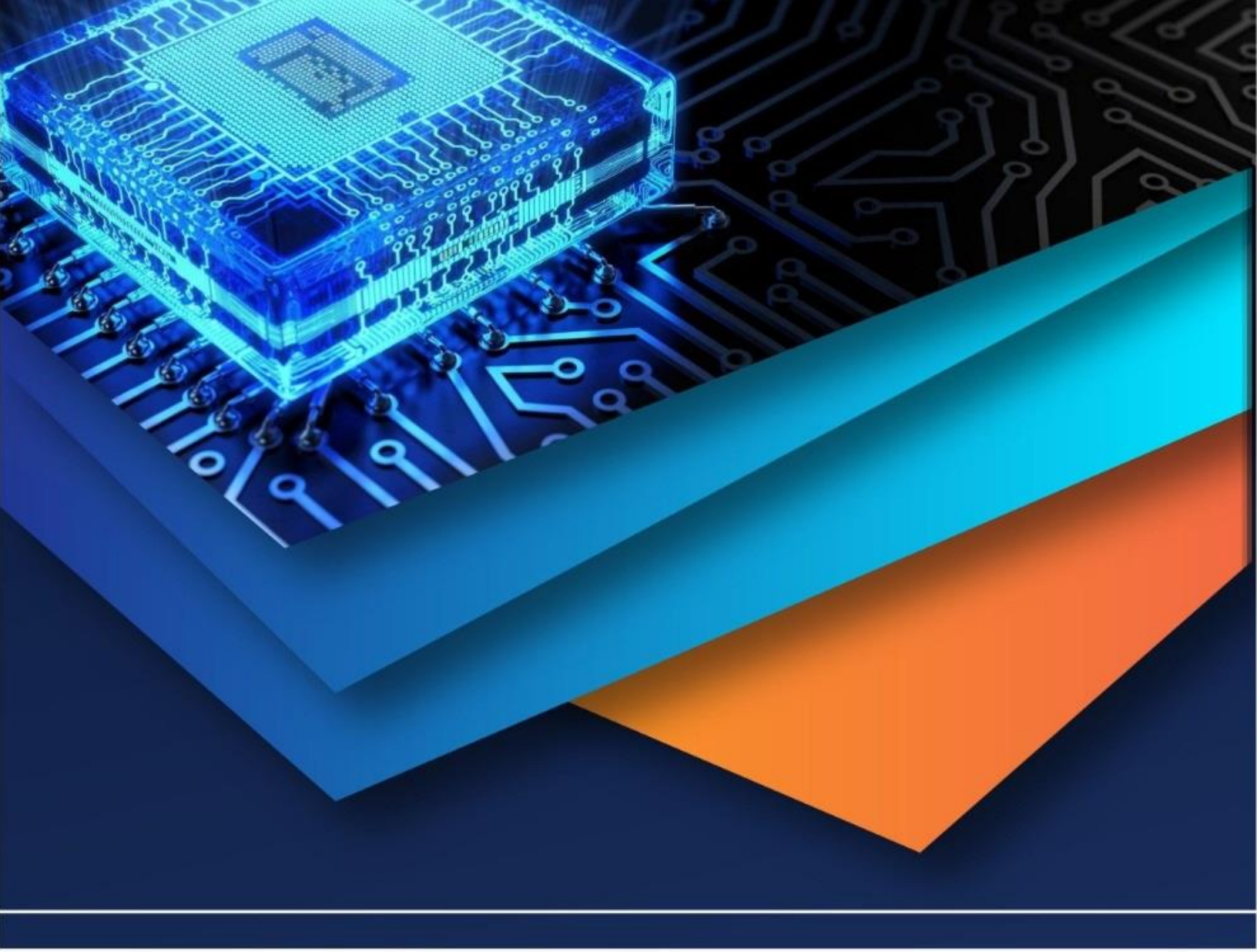

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