Rotating Biological Contactor Wastewater Treatment Using Banana Leaves for Green Areas Irrigation

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Abstract - *The standard of freshwater water per capita globally per year is 1000 m3, various studies expected by year 2025 that freshwater per capita annually in Egypt will be under 600 m3 (Abd elKader and Abd elRassoul, 2010; World Bank, 1995). In Egypt, with the industrial development and population increases, it is expected that both industrial and domestic wastewater will be increased. Therefore, the recycling of those mentioned water sources should be considered as fundamental pillar of water resource policy, thus in this study, two identical stages of the RBCs system were used to treat wastewater after its primary treatment at Zenin wastewater treatment plant in Giza, Egypt. Different materials were used in the treatment process such as geotextile, (in two different forms), circular discs and discs in the form of gear, with 15 discs per RBC stage, a steel cylinder, a plastic bottle with sugarcane straw inside and finally a plastic bottle with banana leaves inside and this will be the main topic of this research. The rotation speed of 5 RPM was used, where it was found later that it gave the best results. The hydraulic retention time ranged between one, two, and three up to seven days. It was found that the best results obtained at HRT of 3 days. Results showed that the removal rates of BOD, COD and TSS were almost 79.16%, 90.6% and 78.95% at 5RPM for banana leaves respectively.*

Key Words: Wastewater Treatment, Rotating Biological Contactor, Banana leaves, Geotextile, Steel Cylinder, Sugarcane Straw, Gear Shaped Geotextile.

1. INTRODUCTION

Rotating biological contactor (RBC) is one way of wastewater treatment ways to be involved after the primary treatment, which is, in order to make it suitable for irrigation purposes. While primary treatment key aim is to eliminate all contaminants that may settle or float, also secondary treatment is intended to eliminate the soluble and colloidal organics that resist primary treatment and to enable further elimination of suspended solids. Those removals are usually occurs by the use of processes of biological treatment. Therefore, wastewater biological treatment is of vital importance for the health of our water.

In order to make the sewage water of Zenin wastewater plant suitable for use in irrigation works, this research aims to treat wastewater using rotating biological contactor (RBC) with banana leaves as RBC media.

A. H. GHAWI and J. KRIŠ (2009), showed the significance of Organic loading parameter. The results proves that the COD removal in rotating biological contactor systems is a function of the organic loading rate. However, both the wastewater concentration and flow rate also influence the system's efficiency, but their impact can be combined by the effects of organic loading. In the system's first stage Most of the removal of the COD occurs. Results also shows that at higher loadings higher concentrations are noted.

S.A. Mirbagheri et al (2016), investigated the denitrification of Tehran (Iran) oil refinery groundwater in an anoxic rotating biological contactor. Different parameters were evaluated such as hydraulic retention time, Carbon/Nitrogen ratio, and nitrate loading. The Nitrate concentration of treated water in all experiments was far below the standard limitation and nitrate removal efficiency reached over 97% in optimum value of Carbon/Nitrogen= 1.25 and HRT = 8 h. Based on that results an anoxic rotating biological contactor could be an adequate and convenient method in denitrification of groundwater.

Jayamala and Nitin A. Deshpande (2016), used attach growth process with Rotating Biological Contactor model to treat domestic sewage. Partially submerged Rotating Biological Contactor showed a removal efficiency for BOD at a rotational speed of disc at 6rpm. The usage of Polyvinyl chloride and polyethylene material resulted in a thick biofilm (Microorganism) growth for effective treatment of sewage. Results also proves that Rotating Biological contactor is efficient, economical and effective in treating organic and inorganic waste.

Juanhong Li and Xiwu Lu (2017), designed a ANF-WDSRBC system combined with an anoxic filter (ANF) and a four stage water dropping self-rotating biological contactor (WDSRBC) as an option for post treatment. Total hydraulic retention time used was 8.8 hrs with a reflux ratio of 1:1. The system was operated 160 days. The system had greater performance without the need for a mechanical aeration devices. The COD, ammonia and total nitrogen removal were 61.4% ± 4.3%, 86.1% ± 3.7%, and 54.5% ± 3.9% respectively. The system had great potential in the decentralized domestic wastewater post-treatment.

Palakshappa.K et al (2019), treated diary wastewater using rotating biological contactor as it's easy to operate, low energy saving and also less area requirement. Three stages RBC were used and kept in series. The RBC disks were 40% submerged and rotating at 40rpm. Different HRT were evaluated to use the optimum HRT which is 8 hrs. Results of Palakshappa.K study showed that COD removal from the three tanks reached 85%, in addition of using the optimum COD loading rate of 1300mg/l the COD removal reached 94%. It can also be concluded that using a three stages rotating biological contactor is an effective and efficient reactor for treating dairy wastewater.

2. Materials and Methodology

2.1. Rotating Biological Contactor (RBC) Model Fabrication

Two identical stage RBC models was fabricated using polyester resin (medium viscosity, medium reactivity) of 10mm thickness for the three sides and a clear acrylic for the fourth side. The model lifted on a steel frame as shown on Fig 1.

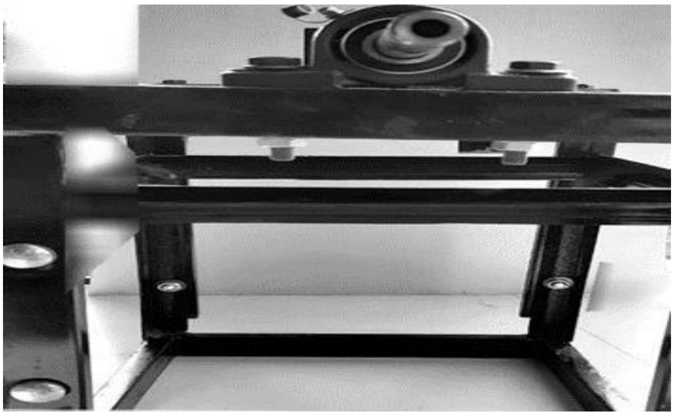

Fig. 1. Steel frame of model

The dimension of individual tank is 35×30×25cm as shown on Fig 2.

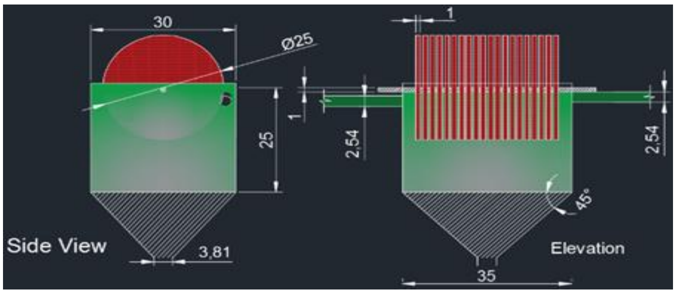

Fig. 2. Model Dimensions

A connection opening was provided between the two tanks of 2.5cm diameter to let the water move from the first stage to the second stage. The inlet and outlet of the model was 2.5cm diameter provided at a height of 2cm from top of first tank for the inlet and at 12.5cm height from top of second tank for outlet. A gap of 35cm was provided between two tanks. Moreover, the proposed RBC has an advantage that, it has an imhoff settling tank in the lower part. Hence, final clarifier therefore is not required. The size of shaft is 2.5cm diameter, which was supported along the frame with bushing and bearings on either side as shown on Fig 3 to hold different shapes of discs. For banana leaves, the rod was replaces with a plastic bottle to hold the leaves inside. A motor is equipped on each tank with a gearbox to allow speed control and for the media to be rotated. A steel frame is used in each tank as for supporting and holding.

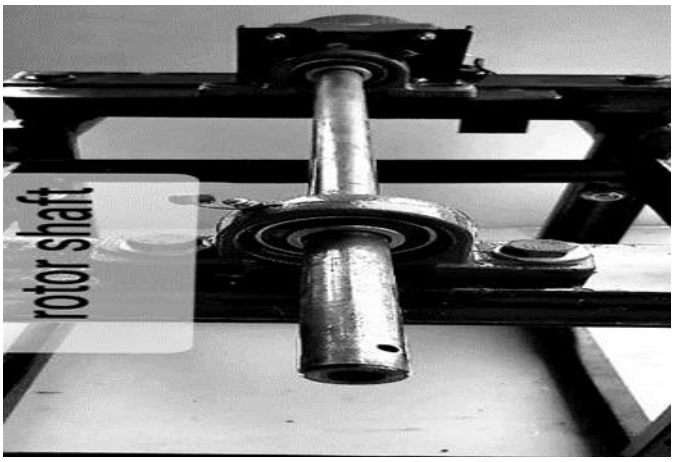

Fig. 3. Rotating shaft

2.2. Materials used

2.2.1. Tank materials

The materials used to construct/fabricate the tanks used on this research is SIROPOL-8340 from Saudi Industrial Resins Limited, which is medium viscosity, medium reactivity, general purpose, unsaturated polyester resin.

The raw materials used in the manufacture of this resin are listed as acceptable in FDA regulation Title 21 CFR 177.2420 for repeated use in contact with food subject to user's compliance with the prescribed limitations of that regulation. Detailed properties of these materials are listed on Table 1 and Table 2.

Table -1: Typical liquid resin properties (25 oC)

Property	Value
Percent Solids	60 – 63 %
Viscosity Brookfield	400 - 500 Cps
Appearance	Clear Yellowish
Acid Value	18 - 23
Specific Gravity	1.04 ± .02
Pounds per Gallon	9.2

Flash Point Range, oC	33

Table -2: Typical physical properties of cured castings

Property	Value	Results	Test Method
Water Absorption (7 day value)	Mg	33	-
Barcol Hardness	-	47	ASTM D-2583
Deflection temperature	oC	60	ASTM D-648
Flexural Strength	N/mm2	106	ASTM D-790
Tensile Strength	N/mm2	68	ASTM D-638
Tensile Elongation %	%	2.2	ASTM D-638

2.2.2. Banana leaves Plastic bottle

For the banana leaves, which is the focus of this research, a plastic bottle with holes on all sides along the length of the basin (RBC stage), with a diameter of 25 cm was filled with banana leaves as shown on Figure 4.

Fig. 4. Banana leaves plastic bottle

2.3. Wastewater Properties

Water used in these experiments is water that was treated in the primary treatment stage and after leaving the primary sedimentation basin from the sewage treatment plant at Zenin, Giza, Egypt. Then, a water pump was used with a flow rate of 0.025 l/s to raise the water to RBC tanks.

Daily incoming water Characteristics to the plant varied according to the source from which that water was produced, according to the quantity produced from homes and factories. The concentration of COD after primary treatment ranges between 250 to 550 mg/l, BOD ranges between 80 to 270 mg/l and TSS ranges between 60 to 260 mg/l.

2.4. RBC Operation

Water was pumped to the RBC tanks through the inlet of the first tank then flow to the second tank through the connection pipe link between both of them. The model was operated for five continuous days without stopping to achieve the steady state conditions. The banana leaves bottle was submerged at 40%. Rotational speed was 5 RPM. The hydraulic retention time ranged from one, two and three days, up to seven days. As the removal rate was stable after the third day, so the optimum hydraulic retention time was chosen to be three days.

Many previous trials were made to find the best rotation speed, the speed of 5 RPM is found to be the optimum rotational speed that gives the best results.

2.5. Samples Collection and Analysis

2.5.1. Samples Collection

Samples were taken from both the first and second RBC tanks, from the water outlet in both tanks. Samples were also taken from the water inlet of the first tank to analyze the water characteristics before any treatment applied. Samples were collected on a daily basis every 24 hours. The pH, COD, BOD and TSS tests were conducted in accordance with international standards for each test that was conducted for all and every sample collected periodically. Results were noted for each day separately with respect to where each sample was taken from. It was also taken into account that the jars used for collecting samples as on Fig 5 do not interact with the collected water and do not change any of its properties or characteristics to ensure that the actual properties are preserved to obtain accurate results.

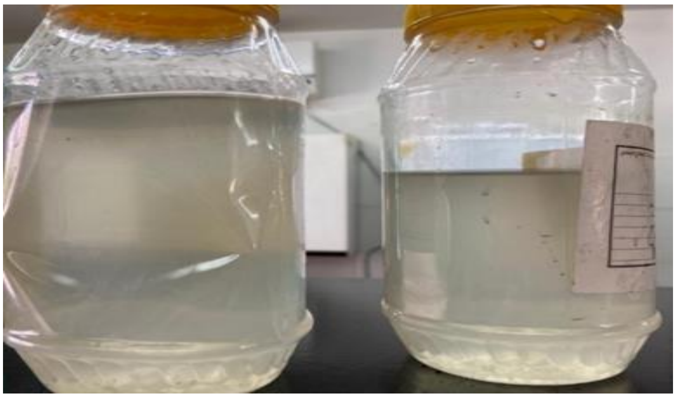

Fig. 5. Samples collection jars

2.5.2. pH analysis

The concentration of hydrogen ion is one of the important indicators of wastewater. The extent of the appropriate focus for the presence of most of the biological life is very small and critical. Waste water with a pH outside the range is difficult to treat in a biological way, and therefore if the (pH) is not adjusted before drainage, it will adversely affect the (pH) in the natural water. pH was measured using pH meter.

2.5.3. BOD analysis

BOD is to measure the dissolved oxygen consumed by microorganisms in the process of biochemical oxidation of organic matter. To measure the absorbed biological oxygen, dilutions of wastewater are made with oxygen-saturated water in special bottles to which bacteria are added. On the other side, a control bottle is filled with water and bacteria only. The bottles are placed in an incubation for five days at a temperature of 20º C, so the process is called the five-day BOD5 tests. The difference between the oxygen concentration in the control bottle and the remaining oxygen in the other bottles after five days is used to calculate the BOD, estimated in mg/L. BOD was measured using dissolved oximeter device.

2.5.4. COD analysis

COD is used to measure the oxygen amount required to chemically oxidize the organic material and inorganic nutrients, such as Ammonia or Nitrate. COD was measured in laboratory in which a sample is incubated with a strong chemical oxidant for a defined time interval and at constant temperature (150°C). Oxidant used is potassium dichromate, in combination with boiling sulphuric acid.

2.5.5. TSS analysis

Wastewater contains a proportion of suspended solids, some of which are suspended Settleable and some not Settleable. The method used to measure TSS is the most common and accurate way, which is by weight. A waste water sample is filtered, dried in a drying oven at 123° C for about an hour, and then weighed.

3. Result and Discussion

Table -3: Wastewater parameters for Run 7 before and after treatment for both phase I and phase II at 5 RPM using banana leaves as media

	In					Out 1 (Phase I)					Out 2 (Phase II)				
Day	pH	Temp C°	COD mg/l	BOD mg/l	TSS mg/l	pH	Temp C°	COD mg/l	BOD mg/l	TSS mg/l	pH	Temp C°	COD mg/l	BOD mg/l	TSS mg/l
Day 1	7.08	26.2	354	80	69	6.82	26	179	45	32	6.80	25.8	52	25	19
Day 2	7.00	26	372	83	73	6.91	25.4	165	44	33	6.90	25.4	45	20	16
Day 3	6.91	25	330	96	76	6.74	25	142	40	33	6.74	25	31	20	16
Day 4	6.96	25.4	456	120	101	6.70	24.8	200	50	46	6.59	24.6	50	27	25
Day 5	7.05	26	326	79	64	6.99	25.6	146	34	31	6.91	25.5	50	18	18
Day 6	7.00	26.2	370	82	69	6.82	25.4	168	37	35	6.74	25.3	57	20	20
Day 7	6.97	27	403	109	94	6.80	26.4	186	54	48	6.74	26.1	62	27	27

For this trial, banana leaves was used as a media for both phase one and phase two. The rotation speed was set to be 5 RPM. Table 3 shows the wastewater parameters before and after treatment for this run.

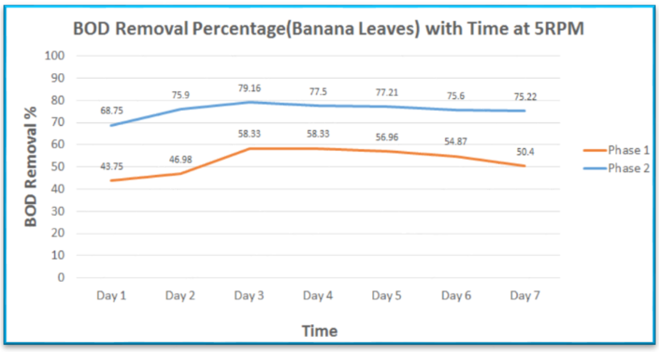

Figure 6: BOD removal percentage with time at 5rpm for Banana Leaves

As presented on Figure 6, BOD removal rates increases over time. However, on the third day the BOD removal rate becomes constant. It is obvious that, the ratio of BOD removal increased from (43.75%) on the first day to (58.33%) on the third day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (68.75%) on the first day to (79.16) on the third day. That means, the best HRT is found to be on the third day, in which the biological layer that is formed on the surface. That layer is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well. The TSS concentration on the third day was 20 mg / l, which does not exceeds 30mg / l, matching the Egyptian specifications for water intended for irrigation purposes.

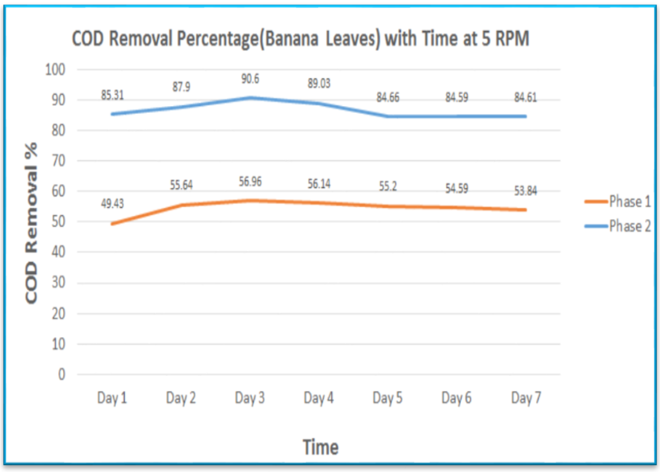

Figure 7: COD removal percentage with time at 5rpm for Banana Leaves

COD removal rates increases over time as per Figure 7. However, on the third day the COD removal rate becomes constant. It is obvious that, the ratio of COD removal increased from (49.43%) on the first day to (56.96%) on the third day and it kept constant after that regarding the first phase. For phase two, the COD removal rate increased from (85.31%) on the first day to (90.6%) on the third day. That means, the best HRT is found to be on the third day, in which the biological layer that is formed on the surface. That layer is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well. The TSS concentration on the third day was 31 mg / l, which does not exceeds 50mg / l, matching the Egyptian specifications for water intended for irrigation purposes.

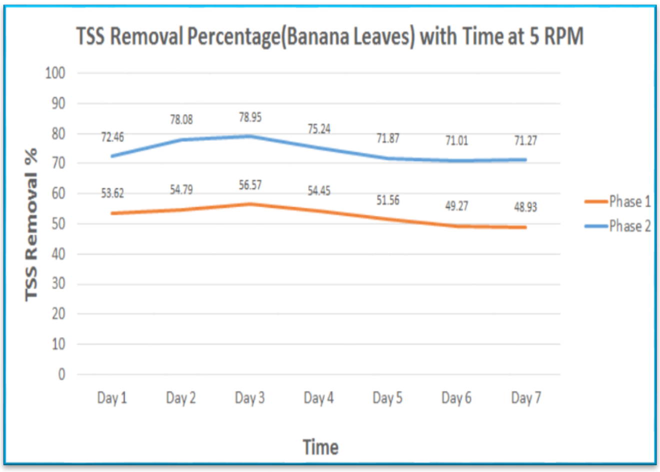

Figure 8: TSS removal percentage with time at 5rpm for Banana Leaves

It can be noted from Figure 8, TSS removal rates increases over time. However, on the third day the TSS removal rate becomes constant. It is obvious that, the ratio of TSS removal increased from (53.62%) on the first day to (56.57%) on the third day and it kept constant after that regarding the first phase. For phase two, the TSS removal rate increased from (72.46%) on the first day to (78.95%) on the third day. That means, the best HRT is found to be on the third day, in which the biological layer that is formed on the surface That layer is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well. The TSS concentration on the third day was 16 mg / l, which does not exceeds 50mg / l, matching the Egyptian specifications for water intended for irrigation purposes.

4. Conclusions

This research has concluded that, rotation speed is a key factor affecting the removal rates for COD BOD and TSS as 5RPM rotation speed showed the higher results. Using two phases rather than one phase greatly contributed to increasing the removal rates of BOD, COD and TSS. As the main aim of this research is to reuse the water for irrigation, the resulted concentrations are completely matching the Egyptian specifications of using treated water for irrigation purpose [ECP 501 – 2015]. The ideal HRT is found to be on the third day of treatment. Removal rates of BOD, COD and TSS using banana leaves were almost 79.16%, 90.6% and 78.95% at 5 RPM respectively.

5. References

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