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Rotating Biological Contactor Wastewater Treatment Using Geotextiles, Sugarcane Straw and Steel Cylinder for Green Areas Irrigation

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Abstract

Due to the recent climatic and economic developments in the Middle East, the region has become on the verge of water poverty. It has become imperative to reconsider the policy of water spending and rationalization of consumption and to consider recycling all types of water, 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, in addition to a plastic bottle with holes with sugarcane straw inside. The rotation speeds were varied between 5, 8 and 10 RPM, with 40% submergence for the geotextile discs of the normal circular shape and for the rest of the materials a rotation speed of 5 RPM were 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 82%, 86.7% and 81.5% at 5RPM for normal circular discs shape respectively, while for gear shaped discs removal rates were almost 83.7%, 91% and 81.3% respectively. For sugarcane straw plastic bottle, BOD, COD and TSS removal rates were almost 64.86%, 69.49 and 68.18% at 5RPM respectively, noting that sugarcane straws removal rates were the lowest among the rest of materials. Removal rates were almost 86.9%, 94.4 and 82.14% for BOD, COD and TSS respectively at 5RPM for steel cylinder. Steel cylinder showed the highest removal rates among all other materials.

Keywords: Rotating Biological Contactor, Wastewater Treatment, Geotextile, Steel Cylinder, Sugarcane Straw, Gear Shaped Geotextile.

1. Introduction

This research discusses one way of waste water treatment ways after its primary treatment which is rotating biological contactor (RBC), in order to make it suitable for irrigation purposes. Primary treatment key aim is to eliminate all contaminants that may settle or float. Secondary treatment is intended to eliminate the soluble and colloidal organics that resist primary treatment and to enable further elimination of suspended solids. Such removals are usually accomplished by the use of processes of biological treatment. Therefore, biological treatment of wastewater is of vital importance for the health of our water bodies.

The objective of this research is to treat sewage water in Zeninwaste water plant in order to make it suitable for use in irrigation works using rotating biological contactor (RBC).

Biological treatment of wastewater is primarily performed by prokaryotes, although fungi, protozoa, algae, and rotifers can also be embodied [1] .By using different metabolic and respiratory processes, the microorganisms absorb carbon and nutrients from sewage. In biological wastewater treatment systems, the most commonly occurring prokaryotes are graded

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as Alpha (α) , Beta (β) and Gamma (√) 9 proteobacteria, Bacteroidetes and Actinobacteria. Municipal wastewater consists of organic content, i.e. carbohydrates. Proteins, oils and fats; nutrients, especially phosphorus and nitrogen; and small quantities of metals and recalcitrant organic compounds [1].

The rotating biological contactor (RBC) process is a secondary biological wastewater treatment system, designed to treat municipal and industrial wastewaters.
Rotating Biological Contactors (RBC) are used to reduce the organic charge in wastewater, thus increasing the concentration of oxygen in wastewater. The raw wastewater first passes through a primary clarifier. The secondary treatment utilizes biological growth attached to media on closely spaced rotating contactor disks mounted on shafts and submerged approximately 40% in the wastewater. As the disks rotate, the attached biomass is alternately exposed to wastewater in the tank and to air above, providing simultaneous oxygen supply and substrate extraction from the wastewater stream for growth and maintenance of the attached organisms. When the growth becomes large enough, fluid shear forces cause portions of biomass to be stripped from the contactor media into the wastewater stream. The sloughed biomass is then separated from the treated carrier stream in a secondary clarifier. The carrier stream effluent is discharged or further treated, and the biological sludge is treated with appropriate processes.

Francis Hassard et al [2], provided a link between disciplines and discuss recent developments in RBC research and comparison of recent process designs. RBC can achieve Full nitrification under appropriate process conditions with oxidation rates up to 6 g m−2 d−1 for municipal wastewater. For nitrogen rich wastewaters RBC has been adapted for denitrification with removal rate up to 14 g m−2 d−1. Selecting for different bacterial groups, different media types can be used to improve organic/nitrogen loading rates. RBC phosphorus removal attained up to 70%. Compared to other biofilm processes, regarding energy consumption RBCs had lowered energy costs than trickling filters by 35% lower but higher demand than wetland systems. 99% of faecal coliforms and the majority of other wastewater pathogens shown to eliminate by RBC systems.

Mangesh Gulhane and Padwekar Karishma G [3], carried out a study to check the feasibility of using rotating biological reactor with some modification for the domestic wastewater treatment. A fixed film biological reactor with rotating paddles was used. The laboratory scale model developed comprises of horizontal and vertical shaft on which rotating paddles were fitted instead of disc. Also artificial media was packed to the paddles to enhance the efficiency. Results revealed that the maximum removal efficiency for BOD and COD was observed to be 85% and 80% at an optimal rotational speed of 7 rpm and detention time of 24 hours. And also the rotating paddles filled with Aerocon stones showed less performance compared to fixed film biological reactor with rotating paddles with plastic media.

ShamasTabraiz et al [4], carried out a study to evaluate the suitability of polyethylene foam as disc material for rotating biological contactors. Also the Dissolved oxygen levels were investigated due to the change in RPM and Submergence. A pilot-scale model of RBC was constructed and operated at different RPM with varying submergence of discs. To run the model domestic sewage was used. Different parameters were monitored such as pH, DO, TSS, BOD and COD. The Optimum values of submergence and RPM were found to be 40% and 5 RPM, respectively. BOD and COD removal, under optimum conditions, were 85.7% and 67.6%, respectively, also concentrations for BOD and COD were 42 and 124 mg/L, respectively. With Dissolved oxygen level of 4.6 mg/L. New disc material used costs US$ 0.38, while conventionally used material, i.e. polystyrene costs US$ 1.91 per square meter. Due to lesser weight energy consumption of newly proposed material is 26 kWh/m3/year while for Polystyrene it is 96.6 kWh/m3/year.

Manoj R. Tonde et al [5], studied parameters that affect performance of the RBC systems like Detention time, rotational speed, influent and effluent waste water characteristics. Biofilm formation on the media and change in the effluent characteristics were also studied for different parameters. The feasibility treatment of waste water by using combinations

within the RBC unit fitted with various operating conditions were also analyzed. Two stages of RBC were used and discs were immersed 40% in the water. Higher BOD and COD removal rate was found for the acrylic discs having sleeves at an angle of 1350 as 80% and 83% respectively.

Martin K Jaison et al [6], used a Rotating Biological Contactor with polypropylene and wool as bio media for treatment of Chemical wastewater from the Caprolactum plant of Fertilizers and Chemical Travancore Limited. Single stage reactor with a total media surface area of 0.24m2 was used. The performance analysis were conducted based on tests on COD, ammonical nitrogen, pH and TSS. The COD removal efficiency was 54% to 76.7%. The analysis made on ammonical nitrogen, TSS and pH reveals that the effluent must be further subjected to denitrification, sedimentation and pH neutralization respectively before disposal.

Palakshappa.K et al [7], 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 waste water.

Sawant N. S and Dr. S. B. Thakare[8], designed a laboratory scale Rotary Biological Contractor in addition to use banana leaves as biological media to treat the Dairy industry wastewater as it contains protein, fats; which are organic in nature and biodegradable and create color and turbidity. The study focused on the removal of BOD, COD, and TS. Due to changes in the Conventional RBC design with the introduction of silts through which air is provided were banana leaves are put as bio-media there was considerable increase in the removal efficiencies.

VahabGhalehKhondabi et al [9], examined the impact of wastewater temperature, rotational speed and disc submergence on phenol and COD removal performance from a petroleum refinery wastewater in Rotating Biological Contactor system. Optimum conditions for phenol and COD removals were statistically obtained at a temperature of 35°C, rotational speed of 11 rpm and disc sub¬mergence of 46%. The result also indicated that, the removal efficiency of phenol, cyanide, ammonia nitrogen, hydrogen sulfide, COD, biological oxygen demand (BOD), total dissolved solid (TDS), total suspended solid (TSS), total organic carbon (TOC) and turbidity respectively were under the 99%, 82%, 40%, 93%, 89%, 87%, 76%, 85%, 55% and 58%.

2. Materials and Methodology

2.1. Rotating Biological Contactor (RBC)Model Fabrication

Twoidentical stage RBC models was fabricated using polyester resin (medium viscosity, medium reactivity) of 10mmthickness for the three sides and a clear acrylic for the fourth side as shown on Fig 1. The model was lifted on a steel frame as shown on Fig 2.

Fig. 1. Two stages RBC model

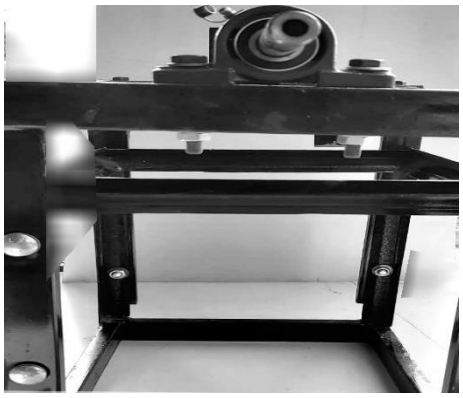

Fig. 2. Steel frame of model

Thedimension of individual tank is 35×30×25cm as shown on Fig 3.

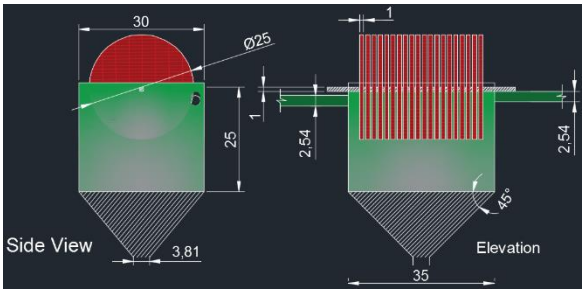

Fig. 3. Model Dimensions

A connection opening was provided between the two tanks of 2.5cm diameterto 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 contains in thelower part an imhoff settling tank. The 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 4. There are 15 discs mounted over the shaft for each stage (Tank) with the size of disc 25cm diameter and 1cm thickness,spacing between 2-discs is 1cm. Disc was constructed with geotextiles and had rough surface area for the attachment and growth of microorganisms. Two shapes of discs were used, one was normal circular shape and the other was a gear shape to increase the attachment and growth of microorganisms. Each type of shape operated separately from each other as it started with normal shape then discs were switched to the gear shaped. For disc and shaft rotating, a motor is equipped on each tank with a gearbox to allow speed control. A steel frame is used in each tank as for supporting and holding.

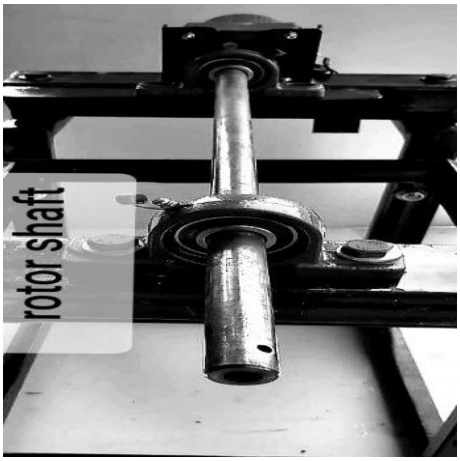

Fig. 4. Rotating shaft

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 °C)

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 (25 °C)

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. Disc materials

Two types of materials are used to construct/fabricate the discs used in RBC models with different fabric weight 800 and 1000 g/m2, the material properties are shown on Table 3. Each disc constructed from two 800 g/m2 plus a 1000 g/m2 in between to shape one disc. Disc raw materials is non-woven needle punched engineered fabrics 100% polypropylene / 100% polyester or blended from both polyester and polypropylene.

Table 3. Disc materials properties

PROPERTY	800	1000	UNIT
Fabric weight	800	1000	g/m2
Thickness under 2KN/m2	7.0	8.5	mm
Grab Tensile strength(M.D)	1800	2100	N
Grab Tensile strength(C.D)	3200	3500	N
Grab Elongation	>80	>75	%
Strip Tensile strength (M.D)	1700	2000	N
Strip Tensile strength (C.D)	3100	3800	N
Puncture Strength	2000	2400	N
Mullen Burst	1100	1300	SPI
Trapezoidal Tear (M.D)	800	1000	N
Trapezoidal Tear (C.D)	1500	1800	N
C.B.R Test	8100	10000	N
Apparent Opening	75	75	micron
Permeability	0.25	0.25	Cm/s
Transmissivity 2KN/m2	380	420	L/M/H

2.2.3. Steel Cylinder

A hollowed-out steel cylinder along the length of the basin (RBC stage), with a diameter of 25cm and has holes on all sides as shown on Fig 5.

2.2.4. Sugarcane straw Plastic bottle

Fig. 5. Steel cylinder

A plastic bottle with holes on all sides along the length of the basin (RBC stage), with a diameter of 25 cm and filled with sugarcane straw.

2.3. Wastewater Properties

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

The Characteristicsof the daily incoming water to the plant vary according to the source from which that water is produced, according to the quantity produced from homes and factories. The concentrationof 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

The water was pumped to the RBC tanks by through the inlet of the first tank and passing to the second tank through the connection pipe link between them. The model was operated for five continuous days without stopping to achieve the steady state conditions. The normal circular shape discs were used in the first trial with 15 disc in each tank with submergence of 40%. Rotational speed ranged between 5, 8 and 10 RPM. The hydraulic retention time ranged from one, two and three days, up to seven days for each rotational speed (RPM). As the removal rate was stable after the third day, so the optimum hydraulic retention time is chosen to be three days.

The previous operations was repeated as a second trial, but only at 5 RPM rotational speed as it is found to be the optimum rotational speed. Discs type also has been changed to be the gear shaped type in order to increase the attachment and growth of microorganisms. Additional types of media was also used such as sugarcane straw plastic bottle, and a steel cylinder. Both have holes and on 5RPM rotation speed.

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 6do 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.

2.5.2. pH analysis

Fig. 6. Samples collection jars

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

3.1. Geotextile Circular Discs

Table 4, 5 and 6 show the water characteristics before and after treatment for both stage I and stage II of RBC within the treatment period at 10 RPM for geotextile circular discs.

Table 4. Water characteristics before and after treatment for geotextile discs at 10 RPM

	Before			After Stage I			After Stage II		
Day	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l
Day 1	381	209	70	220	106	47	60	70	30
Day 2	320	267	60	194	120	43	50	75	28
Day 3	430	110	67	218	46	50	51	29	21
Day 4	330	157	80	183	90	48	44	49	33
Day 5	258	140	86	135	84	51	36	44	36
Day 6	253	156	70	133	79	41	35	50	28
Day 7	250	148	103	130	72	59	35	48	40

Table 5. Water characteristics before and after treatment for geotextile discs at 8 RPM

	Before			After Stage I			After Stage II		
Day	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l
Day 1	387	267	70	219	120	41	97	76	30
Day 2	422	267	60	221	110	33	94	73	20
Day 3	550	120	320	270	48	140	110	33	79
Day 4	258	103	67	129	49	32	54	28	21
Day 5	262	105	260	131	48	130	55	29	89
Day 6	301	94	210	148	47	105	59	26	79
Day 7	267	120	140	133	54	72	52	33	60

Figure 7 represents the relation between BOD removal percentage over time using circular Geotextile disks at 5, 8 and 10 rpm. It is obvious that the percentage of BOD removal increases over time till the third day, while it remains constant till the seventh day. Whereas, the rate of BOD removal on the first day is 40%. While on the third day it was

Table 6. Water characteristics before and after treatment for geotextile discs at 5 RPM

	Before			After Stage I			After Stage II		
Day	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l
Day 1	337	140	146	173	84	108	72	56	70
Day 2	258	100	260	130	57	146	40	31	49
Day 3	253	110	140	94	48	43	35	20	26
Day 4	203	87	167	79	40	72	27	25	36
Day 5	302	97	190	115	46	83	41	28	45
Day 6	254	120	230	94	57	110	35	34	38
Day 7	260	140	152	98	67	80	36	38	48

56.36% in the first phase. Using two phases, it was found that the percentage of BOD removal in the first day was 60%, while on the thirdday it was 81.81% and that's at 5 rpm. Likewise, at 8 rpm, the BOD removal rate for the first and second phases on the first day is 55.05% and 71.53%, respectively, and 60%, 72.5% in the third day for both phases respectively. As for 10 rpm for both the first and second phases, the removal rate is 49.28% and 66.5% respectively for the first day, while on the third day of treatment it was 58.18%, 77.6%, respectively. Also the removal rate kept constant from the third to the seventh day for all phases. That means that the best HRT is found to be on the third day, in which the biological layer that is formed on the surface of the discs is composed of organic materials and bacteria, which give the best removal rates.

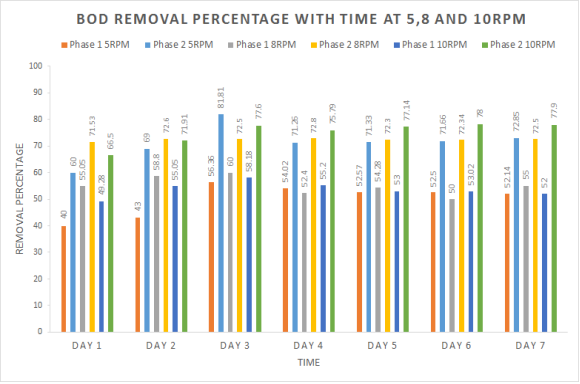

Fig. 7. BOD removal percentage with time at 5, 8 and 10rpm for circular geotextile discs

According to the Egyptian specifications for water intended for irrigation purposes[10], the permissible concentration for BOD cannot exceed 30 mg / l. And where the result of the third day was the best result, the BOD concentration at 5 rpm was 20 mg / l, so that concentration becomes within the permissible

limits according to the specifications. At 8 rpm, the BOD concentration was 33 mg / l and thus exceeded the permissible limits. Finally, at 10 rpm, the BOD concentration was 29 mg / l, and it was within the permissible limits also according to the specifications of water used for irrigation purposes. So the best results is found to be at 5 rpm.

Figure 8 represents the relation between COD removal percentage over time using circular Geotextile disks at 5, 8 and 10 rpm. It is obvious that the percentage of COD removal increases over time till the third day, while it remains constant till the seventh day. Whereas, the rate of COD removal on the first day is 48.6%. While on the third day it was 62.84% in the first phase. Using two phases, it was found that the percentage of COD removal in the first day was 78.6%, while on the third day it was 89.166% and that's at 5 rpm. Likewise, at 8 rpm, the COD removal rate for the first and second phases on the first day is 43.4% and 74.9%, respectively, and 48.9%, 80% in the third day for both phases respectively. As for 10 rpm for both the first and second phases, the removal rate is 42.25% and 84.25% respectively for the first day, while on the third day of treatment it was 49.3%, 88.13%, respectively. Also the removal rate kept constant from the third to the seventh day for all phases. That means that the best HRT is found to be on the third day, in which the biological layer that is formed on the surface of the discs is composed of organic materials and bacteria, which give the best removal rates.

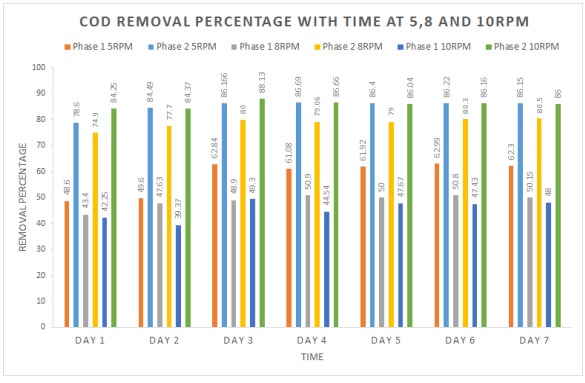

Fig. 8. COD removal percentage with time at 5, 8 and 10rpm for circular geotextile discs

According to the Egyptian specifications for water intended for irrigation purposes [10], the permissible concentration for COD cannot exceed 50 mg / l. And where the result of the third day was the best result, the COD concentration at 5 rpm was 35 mg / l, so that concentration becomes within the permissible limits according to the specifications. At 8 rpm, the BOD concentration was 110 mg / l and thus exceeded the permissible limits. Finally, at 10 rpm, the BOD concentration was 51 mg / l, and it was within the permissible limits also according to the specifications of water used for irrigation purposes. So the best results is found to be at 5 rpm.

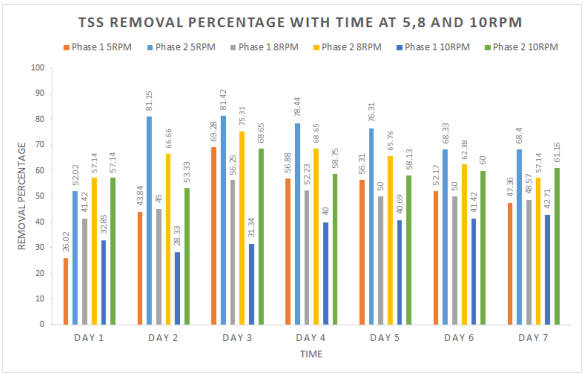

Fig. 9. TSS removal percentage with time at 5, 8 and 10rpm for circular geotextile discs

Figure 9 represents the relation between TSS removal percentage over time using circular Geotextile disks at 5, 8 and 10 rpm. It is obvious that the percentage of TSS removal increases over time till the third day, while it remains constant till the seventh day. Whereas, the rate of TSS removal on the first day is 26.02%. While on the third day it was 69.28% in the first phase. Using two phases, it was found that the percentage of TSS removal in the first day was 52.02%, while on the third day it was 81.42% and that's at 5 rpm. Likewise, at 8 rpm, the TSS removal rate for the first and second phases on the first day is 41.42% and 75.14%, respectively, and 56.25%, 75.13% in the third day for both phases respectively. As for 10 rpm for both the first and second phases, the removal rate is 32.85% and 57.14% respectively for the first day, while on the third day of treatment it was 31.34%, 68.65%, respectively. Also the removal rate kept constant from the third to the seventh day for all phases. That means that the best HRT is found to be on the third day, in which the biological layer that is formed on the surface of the discs is composed

of organic materials and bacteria, which give the best removal rates.

According to the Egyptian specifications for water intended for irrigation purposes [10], the permissible concentration for TSS cannot exceed 50 mg / l. And where the result of the third day was the best result, the TSS concentration at 5 rpm was 26 mg / l, so that concentration becomes within the permissible limits according to the specifications. At 8 rpm, the TSS concentration was 110 mg / l and thus exceeded the permissible limits. Finally, at 10 rpm, the TSS concentration was 79 mg / l, and it was within the permissible limits also according to the specifications of water used for irrigation purposes. So the best results is found to be at 5 rpm.

3.2. Geotextile Gear-Shaped Discs

Table 7 show the water characteristics before and after treatment for both stage I and stage II of RBC within the treatment period at 5 RPM for gear shaped geotextile discs.

Table 7. Water characteristics before and after treatment for gear shaped geotextile discs at 5 RPM

	Before			After Stage I			After Stage II		
Day	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l
Day 1	417	74	48	192	29	32	72	22	17
Day 2	514	148	120	190	53	70	70	27	32
Day 3	404	159	160	143	41	80	37	26	30
Day 4	378	118	140	134	34	80	35	22	30
Day 5	345	107	97	123	32	57	32	21	26
Day 6	370	105	84	132	31	50	34	21	25
Day 7	362	101	76	129	30	46	33	21	25

It can be noted from Figure 10, 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 (60.8%) on the first day to (71.9%) on the third day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (70.2%) on the first day to (83.64%) 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 of the discs is composed

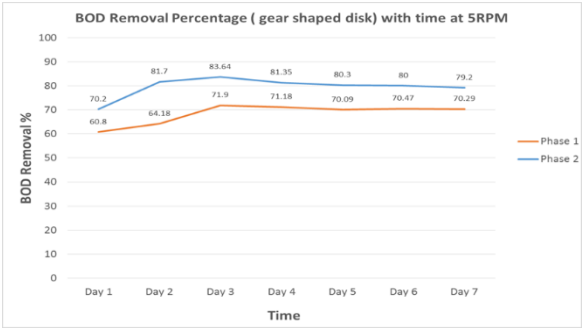

Fig. 10. BOD removal percentage with time at 5rpm for gear-shaped geotextile discs

of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well .The BOD concentration on the third day was 26mg / l, which does not exceed 30mg / l, matching the Egyptian specifications for water intended for irrigation purposes [10].

It can be noted from Figure 11, COD removal rates increases over time. However, on the third day the COD removal rate becomes constant. It is obvious that, the ratio of BOD removal increased from (53.9%) on the first day to (64.6%) on the third day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (82.73%) on the first day to (90.8%) 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 of the discs is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well .The BOD concentration on the third day was 37mg / l, which does not exceed 50mg / l, matching the Egyptian specifications for water intended for irrigation purposes [10].

It can be noted from Figure 12, 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 (33.33%) on the first day to (50%) on the fourth day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (64.58%) on the first day to (81.25%) 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 of the discs is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well .The BOD concentration on the third day was 30mg / l, which does not exceed 50mg / l, matching the Egyptian specifications for water

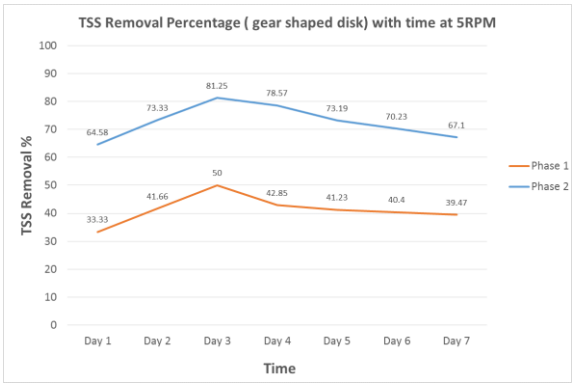

Fig. 12. TSS removal percentage with time at 5rpm for gear-shaped geotextile discs

intended for irrigation purposes [10].

3.3. Steel Cylinder

Table 8 show the water characteristics before and after treatment for both stage I and stage II of RBC within the treatment period at 5 RPM for the steel cylinder

Table 8. Water characteristics before and after treatment steel cylinder at 5 RPM

	Before			After Stage I			After Stage II		
Day	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l
Day 1	417	74	48	192	29	32	72	22	17
Day 2	514	148	120	190	53	70	70	27	32
Day 3	404	159	160	143	41	80	37	26	30
Day 4	378	118	140	134	34	80	35	22	30
Day 5	345	107	97	123	32	57	32	21	26
Day 6	370	105	84	132	31	50	34	21	25
Day 7	362	101	76	129	30	46	33	21	25

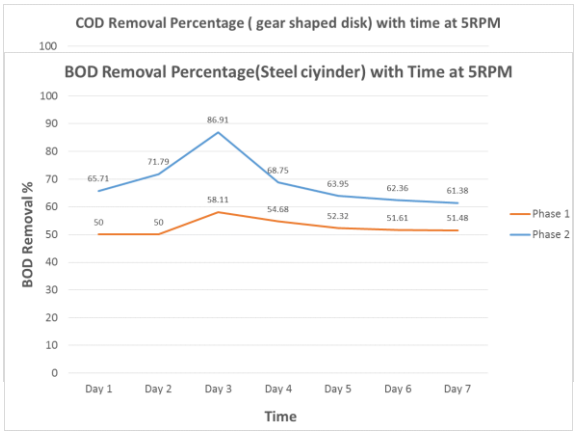

Fig. 13. BOD removal percentage with time at 5rpm for steel cylinder

It can be noted from Figure 13, 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 (50.0%) on the first day to (58.11%) on the third day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (65.71%) on the first day to (86.91%) 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 of the discs is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well .The BOD concentration on the third day was 25mg / l, which does not exceed 30mg / l, matching the Egyptian specifications for water intended for irrigation purposes [10].

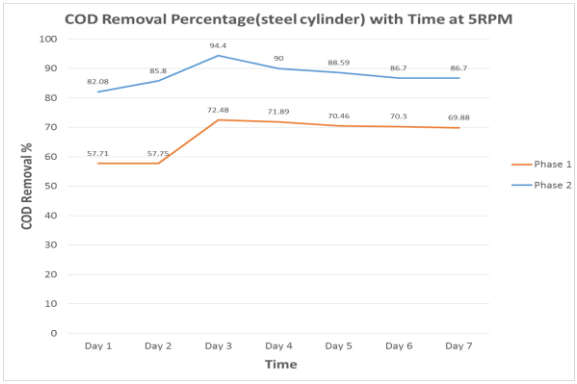

Fig. 14. COD removal percentage with time at 5rpm for steel cylinder

It can be noted from Figure 14, COD removal rates increases over time. However, on the third day the COD removal rate becomes constant. It is obvious that, the ratio of COD removal increased from (57.71%) on the first day to (72.48%) on the third day and it kept constant after that regarding the first phase. For phase two, the COD removal rate increased from (82.08%) on the first day to (94.4%) 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 of the discs is composed of organic materials and bacteria, which give the best removal rates in order to bear that layer of organic loads well .The COD concentration on the third day was 25mg / l, which does not exceed 50mg / l, matching the Egyptian specifications for water intended for irrigation purposes [10].

It can be noted from Figure 15, 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 (34.78%) on the first day to (53.57%) on the third day and it kept constant after that regarding the first phase. For phase two, the COD removal rate increased from (63.04%) on the first day to (82.14%) 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 of the discs 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 15 mg / l, which does not exceed 50mg / l, matching the Egyptian specifications for water intended for irrigation purposes [10].

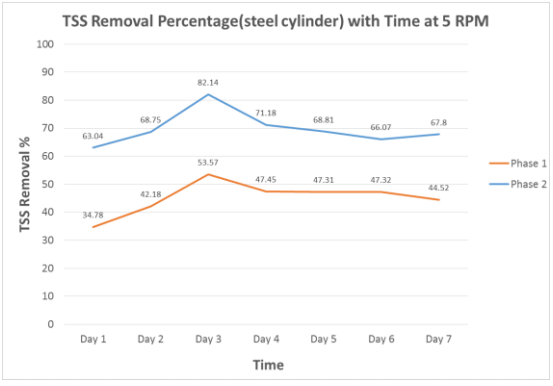

Fig. 15. TSS removal percentage with time at 5rpm for steel cylinder

3.4. Sugarcane Straw

Table 9 show the water characteristics before and after treatment for both stage I and stage II of RBC within the treatment period at 5 RPM for the sugarcane straw

Table 9. Water characteristics before and after treatment sugarcane straw at 5 RPM

	Before			After Stage I			After Stage II		
Day	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l	COD mg/l	BOD mg/l	TSS mg/l
Day 1	417	74	48	192	29	32	72	22	17
Day 2	514	148	120	190	53	70	70	27	32
Day 3	404	159	160	143	41	80	37	26	30
Day 4	378	118	140	134	34	80	35	22	30
Day 5	345	107	97	123	32	57	32	21	26
Day 6	370	105	84	132	31	50	34	21	25
Day 7	362	101	76	129	30	46	33	21	25

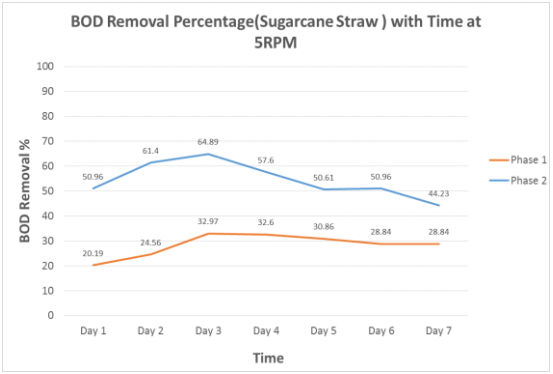

Fig. 16. BOD removal percentage with time at 5rpm for sugarcane straw

It can be noted from Figure 16, 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 (20.19%) on the first day to (28.84%) on the third day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (50.96%) on the first day to (64.89%) 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 of the discs 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 33 mg / l, which does exceeds 30mg / l, not matching the Egyptian specifications for water

intended for irrigation purposes [10].

It can be noted from Figure 17, COD removal rates increases over time. However, on the third day the COD removal rate becomes constant. It is obvious that, the ratio of COD removal increased from (22.8%) on the first day to (44.29%) on the third day and it kept constant after that regarding the first phase. For phase two, the COD removal rate increased from (61.43%) on the first day to (69.49%) 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 of the discs 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 115 mg / l, which does exceeds 50mg / l, not matching the Egyptian specifications for water intended for irrigation purposes [10].

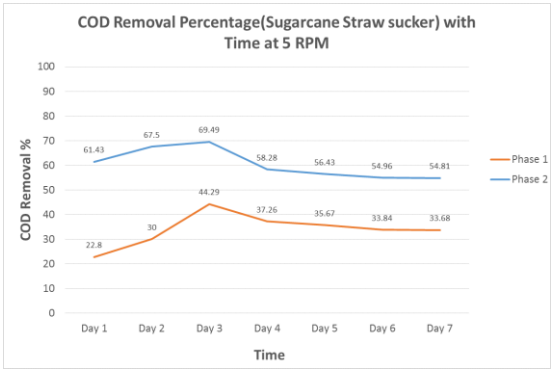

Fig. 17. COD removal percentage with time at 5rpm for sugarcane straw

It can be noted from Figure 18, 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 (25.92%) on the first day to (34.55%) on the third day and it kept constant after that regarding the first phase. For phase two, the BOD removal rate increased from (62.03%) on the first day to (68.18%) 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 of the discs 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 28 mg / l, which does not exceeds 50mg / l, matching the Egyptian specifications for water intended for irrigation purposes [10].

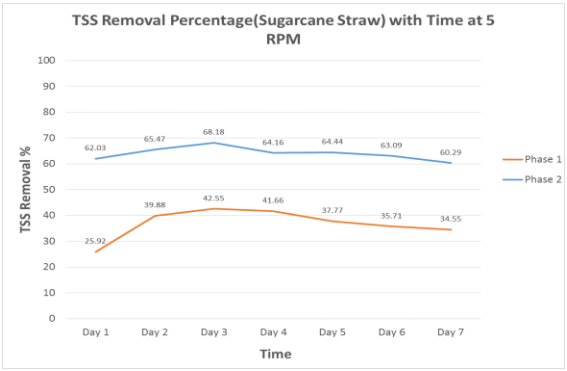

Fig. 18. TSS removal percentage with time at 5rpm for sugarcane straw

3.5. Phase 2, 5 RPM for All Materials

Referring to the previous charts, the best HRT was found to be on the third day, and since the removal rates increases significantly in the second stage, it can be concluded that the best removal rates occurs in the second phase on the third day of treatment. Figure 19 shows the BOD removal rates on the third day of the second phase for each of the circular geotextile discs, the gear-shaped discs, the steel cylinder and the sugarcane straw and were 81.81%, 83.64%, 86.91% and 64.89% respectively. By comparing results, it becomes clear that the best material is the steel cylinder.

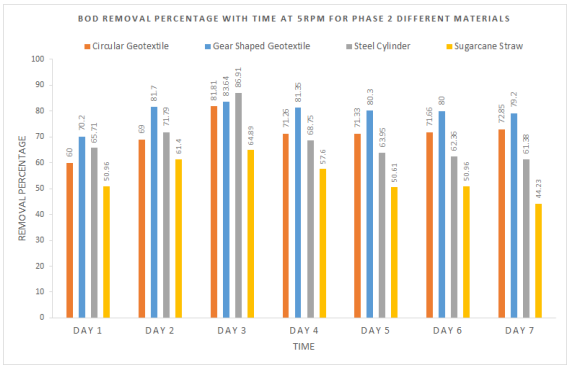

Fig. 19. BOD removal percentage with time at 5rpm and phase 2 for all materials

Referring to the previous charts, the best HRT was found to be on the third day, and since the removal rates increases significantly in the second stage, it can

be concluded that the best removal rates occurs in the second phase on the third day of treatment. Figure 20 shows the COD removal rates on the third day of the second phase for each of the circular geotextile discs, the gear-shaped discs, the steel cylinder and the sugarcane straw and were 86.166%, 90.8%, 94.4% and 69.49% respectively. By comparing results, it becomes clear that the best material is the steel cylinder.

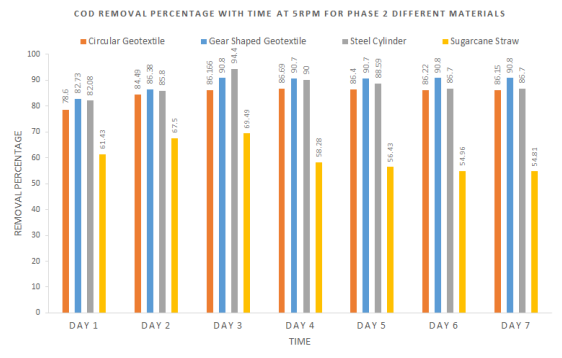

Fig. 20. COD removal percentage with time at 5rpm and phase 2 for all materials

Referring to the previous charts, the best HRT was found to be on the third day, and since the removal rates increases significantly in the second stage, it can be concluded that the best removal rates occurs in the second phase on the third day of treatment. Figure 21 shows the TSS removal rates on the third day of the second phase for each of the circular geotextile discs, the gear-shaped discs, the steel cylinder and the sugarcane straw and were 81.42%, 81.25%, 82.24% and 68.18% respectively. By comparing results, it becomes clear that the best material is the steel cylinder.

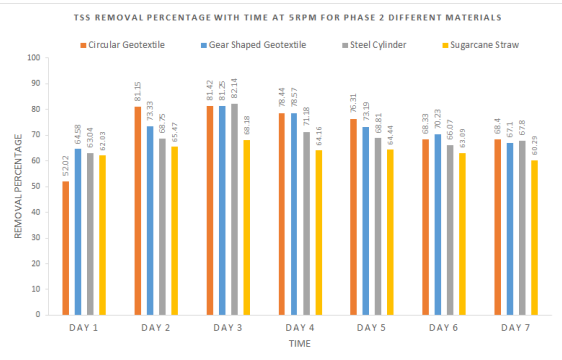

Fig. 21. TSS removal percentage with time at 5rpm and phase 2 for all materials

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. Also the discs shapes greatly affects the results positively due to the increase in surface area which the gear shaped discs showed, thus the greater the surface area, the greater efficiency of treatment. 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 [10]. The ideal HRT is found to be on the third day of treatment. Removal rates of BOD, COD and TSS were almost 86.9%, 94.4 and 82.14% at 5RPM respectively for streel cylinder, which showed the highest removal rates among all other materials.

5. Conflicts of interest

There are no conflicts to declare

6. References

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ملخص عربى

الماء عنصر أساسي لإستمرارية الحياة ومصدر هام من مصادر قيام الحضارات وحتي عصر قريب لم تكن مصر تعاني من أعراض الفقر المائي ولكن نظراً للتطورات المناخيه والإقتصاديه الأخيرة في منطقة الشرق الأوسط فقد أضحت المنطقة علي مشارف الفقر المائي. وقد أصبح من الحتمي إعادة النظر في سياسة الإنفاق المائي وترشيد الأستهلاك والنظر في إعادة تدويرجميع انواع المياه اولذلك تم عمل وحدتين من الأقراص الدوارة على التوالى وتم استخدام مختلف من المواد فى عمل الأقراص للوحدتين منها التكسية الأرضية (geotextile) فى شكلين مختلفين أقراص دائرية وأقراص على شكل تروس وكل وحدة تحتوى على خمسة عشر قرص قطر وايضا أسطوانة حديدية لكل وحدة وزجاجة بلاستيكية بها فتحتات كان بداخلها مصاصة قصب لكل وحدة وكانت نسبة الغمر 40% والسرعات المستخدمة 5-8-10 لفة فى الدقيقة للاقراص الدائرية من geotextile وكانت 5 لفة فى الدقيقة هى من أعطت افضل نتائج لذلك تم استخدامها لباقى المواد المستخدمة تم عمل الاختبارات للمياه الناتجة خلال سبع أيام بعد تركها خمسة أيام لتكون الميديا وأظهرت النتائج ان أفضل يوم هو اليوم الثالث من النتائج و أظهرت النتائج أن معدلات إزالة BOD و COD و TSS كانت حوالي 82٪ و 86.7٪ و 81.5٪ عند 5 دورة في الدقيقة لشكل الأقراص الدائرية العادية على التوالي ، بينما كانت معدلات إزالة الأقراص على شكل تروس 83.7٪ و 91٪ و 81.3٪ على التوالي ،بالنسبة للزجاجة البلاستيكية التى تحتوى على مصاصة القصب كانت معدلات إزالة BOD و COD و TSS تقريبًا 64.86٪ و 69.49 و 68.18٪ عند 5 دورة في الدقيقة على التوالي ، مع ملاحظة أن معدلات إزالة مصاصة القصب كانت الأقل بين بقية المواد. كانت معدلات الإزالة 86.9٪ و 94.4 و 82.14٪ BODو COD و TSS على التوالي عند 5 دورة في الدقيقة للأسطوانة الحديدية. أظهرت الأسطوانة االحديدية أعلى معدلات الإزالة بين جميع المواد الأخرى.