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Simple Treatment of Agricultural Drains Wastewater using Rotating Paddles

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***Abstract*—** *With the population growth, the increase in their activities and civilization raised their water need. With the shortage in new water resources for reuse and high cost for the desalination methods for sea water leads to the depend on the wastewaters with all its types. The huge costs for treating both municipal and industrial wastewaters to be reusable for human needs open the door for treating the agriculture drains water which is bigger in amount and lower in pollution to introduce a huge source for water. Several procedures had been applied to encourage its own self purification system to overcome the pollutants faster and left the stream clean for human purposes as much as possible. This study used the natural rotating paddles to enhance the stream water body quality and improve it for reuse purposes. Generally, the study shows that the temperature of air and water had no effect on the treatment or by it. Also, the pH value did not affect by the applied treatment or on it. While the TDS were affected slightly by the treatment with very low margin between 1- 4 %. The system succeeded to improve DO by 82%. Decrease the BOD, COD & TSS by 85% with the four serial paddles and 68% of the heavy metals from drain water that achieved very high treatment and fast the possibility of drain water reuse*.

I. INTRODUCTION

It is impossible to imagine life without water, but unfortunately some countries, including Egypt, are suffering from many problems such as lack of resources and contamination of different water bodies due to lack of good treatment. Water pollution is a change in the natural qualities of the water from the taste, color and odor. This pollution occurs when the human discharge contaminants into the water and this negatively affects the lives of all living and human beings [1]. Main water pollution sources are [2] natural source, agricultural source, industrial wastewater source, domestic wastewater source and other minor sources. Sewage water is treated since long time and reused in irrigation and land reclamation. Industrial wastewater can be treated and reused in industry.

Agricultural pollution practices have come up due to the increase in the demand for food which is proportional to the increase in population. To increase the farms productivity, the farmers have had to resort to additional chemical fertilizers, pesticides, weedicides, hormonal treatments for the animals, nutrient laden feed and many such practices which changed the traditional way of farming. This contamination is dangerous to all living organisms that depend on the food on cultivation. Treatment of agricultural wastewater is still under investigation and will be the target of this paper.

With the population growth, the increase in their activities that need water, the increase in pollution for all water bodies around the world and with the shortage in water resources to meet this growth and recover the human activities pollution growth, the reuse of all types of wastewaters became a main issue. The huge costs for treating both municipal and industrial wastewaters to be reusable for human needs open the door for treating the agriculture drains water which is bigger in amount with lower in pollution that ease its treatment and introduce a huge source for water. Several procedures had been applied specially with the phenomena that each stream has his own self purification system prepared by god to overcome the pollutants and left the stream clean for human purposes as much as possible.

Before the bad attitude of humanity in its dealing with the stream bodies man can drink directly from any stream body with no harm. But after the use of these bodies as the big huge garbage basket for all our wastes depending on the self-purification prepared by god, make the steams suffers from the big amounts of pollutants that takes from the self-purification system kilometers to recover the stream criteria and with the increase of pollutants and the points and non-points of pollution on it the self-purification system failed in its job. This raises the need to treat water inside agricultural drains to help self-purification to stand again and to ease the reuse of this water again.

Oxygen usually comes from the atmosphere; in which case the process is called water aeration. Typically, wastewater does not contain gaseous oxygen due to organic pollutant loads. Dissolved oxygen is found naturally only in clean natural water or non-contaminated. The amount of water aeration is estimated by the oxygen capacity [3].

To ensure continuous contact between the organic matters and bacteria, constant stirring is required to ensure continuous oxygenation of the air colony needed by the biodegradable action. In addition to stirring and aeration, the mixture in the stream aims to maintain a semi-static concentration of activated sludge as a result of recycling part of the sludge by the stirring effect. In general, the equipment works in water and under the influence of atmospheric oxygen. For this reason, prefer corrosion-resistant materials, such as stainless steel, cast iron, bronze and other non-ferrous materials such as ceramic, plastic and others [3]. Several applications for rotors had been made in different sites that were made by natural rotors that rotate due to the stream flow velocity effect and succeeded to increase the do in the stream by 12-15 % of its existing value. The application of electric operating rotors increased the additional DO in the stream flow to 20-25 % its

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existing value due to the rotating speed that varied from 10 -30 rpm in an experiment made in Fayoum baher Yousef canal in 2007 [4].

II. Materials and Methods

The study location was Bahr El Baqar agricultural drain, where the using pilot plant funded by EU research project was constructed near the drain inside Faqous wastewater treatment plant in Al Sharqih Governorate, Egypt.

The pilot plant was operated in the field under the nature conditions like temperature, sunlight, duration and humidity according to study location and drain conditions in the study period.

The experimental work has been implemented on a pilot plant unit. The pilot consisted from a submersible pump erected inside the drain above the bed by 50 cm. The pump feeds cross channel that feed five parallel channels with dimensions of 40cm width, 70cm depth and length of 10m water comes from the beginning, Sewage disposed agricultural wastewater to the pilot presented from the influent point, that ended by another cross channel that drained with gravity pie again to the drain.

Figure (1) illustrated photo for the pilot channels. The applied solutions are put in four from the five parallel channels after its starting edge by 0.5 m with variable length from 0.5 to 1.9 m.

Pilot components details are illustrated as follows:

- *Feeding Pump*

Using submersible pump of 10 l/s and head 10 m takes water from drain to channels by force main pipe of 4-inch diameter.

- *Channels*

Five parallel channels with dimensions of 40cm width, 70cm depth and length of 10m water

- *Used Treatment Unit*

Erecting treatment unit after water channel inlet by 0.5 m up to 1.90m.

- *Disposal Pipe*

The 6 inch pipe takes the treated water and throws it into the drain again

Figure (1) Photo of the Applied Pilot

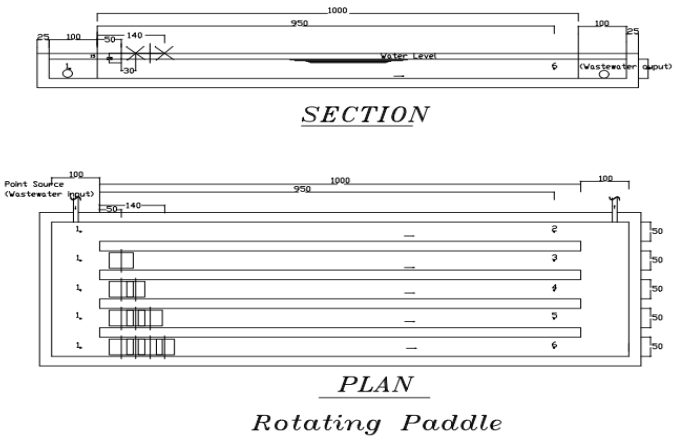
III. Experimental Work

The study used a solution of the rotating paddles for agricultural drain wastewater treatment to check its applicability technically, economically and environmentally.

Using lightly rotating paddles which used water velocity to push it to rotate with different number of impellers in each channel one, two, three & four in series. Each paddle with length inside water by 15 cm. Figure (2) shows application of rotating paddles in the study pilot.

Rotating paddles was applied on the five water ways of the pilot where one of them was left without any adding of paddles as buffer, other four were using rotating paddles by put one in the first channel, two in the second, three in the third and four serial paddles in the fourth channel. The experiment continues until the system reaches its steady state condition.

Sample from the raw water coming from the drain entering the system is obtained for analyses. Another samples were taken from the end of each channel to measure the treatment effect. Two different samples are taken three times a week from different locations to measure parameters and their changes.



Channel No.	Treatment Method (Rotating Paddles)
1	Without treatment
2	One impeller paddle
3	Two impellers paddles
4	Three impellers paddles
5	Four impellers paddles

Figure (2) Application of rotating paddles in the study pilot

In this method using rotating paddles as an aerated equipment which used water velocity to push it to rotate with different number of impellers in each channel. The experiment covers period of six weeks from 1st of March to 12th of April 2020.

IV. Results & Discussion

Generally, the study shows that the temperature of air and water had no effect on the treatment or by it. Also, the pH value did not affected by the applied treatment or on it. While the TDS were affected slightly by the treatment with very low margin between 1- 4 %.

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Table (1) shows the daily results of DO analysis. Figure (3) illustrates the average DO variations in the experiment.

Table (1) DO in Rotating Paddles Experiment

Day		Raw water	Effluent water				
			Ch1	Ch2	Ch3	Ch4	Ch5
Week 1	1	0.5	0.5	1.2	1.3	1.4	1.6
	2	0.6	0.6	1.3	1.3	1.4	1.6
	3	0.5	0.5	1.3	1.4	1.5	1.6
	4	0.6	0.6	1.3	1.4	1.5	1.6
	5	0.6	0.6	1.3	1.3	1.4	1.6
	6	0.6	0.6	1.3	1.3	1.4	1.7
Week 2	8	0.7	0.7	1.4	1.4	1.5	1.6
	9	0.8	0.8	1.2	1.4	1.5	1.6
	10	0.8	0.8	1.3	1.3	1.4	1.6
	11	0.9	0.9	1.3	1.3	1.4	1.6
	12	0.9	0.9	1.3	1.4	1.5	1.6
	13	0.9	0.9	1.3	1.4	1.5	1.7
Week 3	15	0.9	0.9	1.3	1.3	1.4	1.6
	16	0.9	0.9	1.3	1.3	1.4	1.6
	17	0.9	0.9	1.3	1.4	1.5	1.6
	18	0.9	0.9	1.3	1.3	1.5	1.6
	19	0.9	0.9	1.3	1.3	1.4	1.6
	20	0.9	0.9	1.4	1.4	1.5	1.7
Week 4	22	0.9	0.9	1.4	1.4	1.5	1.6
	23	0.9	0.9	1.4	1.4	1.5	1.6
	24	0.9	0.9	1.4	1.4	1.5	1.6
	25	0.9	0.9	1.4	1.4	1.5	1.7
	26	0.9	0.9	1.4	1.4	1.5	1.7
	27	0.9	0.9	1.5	1.5	1.6	1.7
Week 5	29	0.9	0.9	1.4	1.4	1.5	1.7
	30	0.9	0.9	1.4	1.4	1.5	1.7
	31	0.9	0.9	1.4	1.4	1.5	1.7
	32	0.9	0.9	1.5	1.5	1.6	1.8
	33	0.9	0.9	1.5	1.5	1.6	1.8
	34	0.9	0.9	1.5	1.5	1.6	1.8
Week 6	36	0.9	0.9	1.4	1.5	1.6	2
	37	0.9	0.9	1.4	1.5	1.6	2
	38	0.9	0.9	1.4	1.5	1.6	2
	39	0.9	0.9	1.5	1.5	1.6	2
	40	0.9	0.9	1.5	1.5	1.6	2
	41	0.9	0.9	1.5	1.5	1.6	2
Average		**0.83**	**0.83**	**1.37**	**1.40**	**1.50**	**1.71**

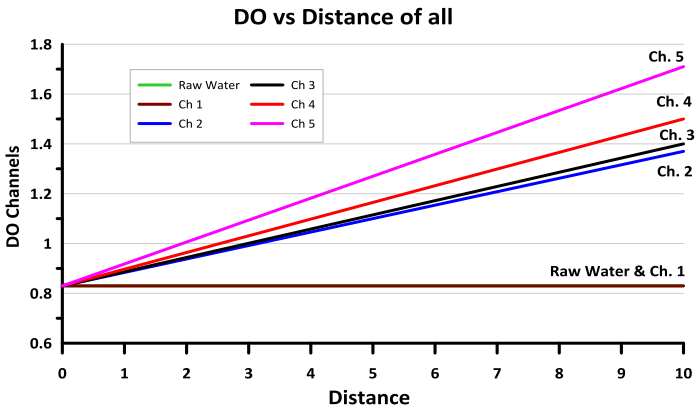

Figure (3) Average DO Variations with Different Number of Rotating Paddles.

DO increased with rotating paddles in general between 1.2, 2.0 mg/l according to number of impellers. With one rotating impeller, it reached 1.2, 1.5 mg/l with an average increase ratio 65.1%. The value of DO varied between 1.3, 1.5 mg/l in case of two impellers with an average increase ratio 68.7%. When rotating paddles impellers was increased to three, DO reached between 1.4, 1.6 mg/l with an average increase ratio 80.72%. The maximum value of DO was between 1.6, 2.0 mg/l and occurred when the number of impellers was four with an average increase ratio was 106%. It is clear from the results that the greater number of impellers has a direct effect in increasing DO in water.

Table (2) shows the daily results of BOD analysis and Figure (4) illustrates the average BOD variations in the experiment for raw & effluent water in all channels in the run period from March to April 2020.

Table (2) BOD in Rotating Paddles Experiment

Day		Raw water	Effluent water				
			Ch1	Ch2	Ch3	Ch4	Ch5
Week 1	1	460	460	300	240	160	90
	2	440	440	280	240	140	80
	3	450	450	290	250	150	80
	4	460	460	300	260	160	80
	5	460	460	300	260	160	80
	6	465	465	305	260	160	80
Week 2	8	470	470	300	250	170	80
	9	470	470	300	260	170	80
	10	490	490	310	260	190	80
	11	500	500	300	250	160	80
	12	490	490	280	260	170	80
	13	480	480	280	260	170	70
Week 3	15	480	480	280	250	190	70
	16	490	490	310	260	160	70
	17	490	490	310	260	170	70
	18	490	490	310	250	170	70
	19	500	500	320	260	190	70
	20	500	500	320	260	160	70
Week 4	22	500	500	320	250	170	70
	23	490	490	310	260	170	70
	24	500	500	320	260	190	70
	25	510	510	320	250	160	70
	26	500	500	320	260	170	70
	27	500	500	320	260	170	70
Week 5	29	500	500	320	250	190	70
	30	500	500	320	260	160	70
	31	510	510	320	260	170	70
	32	510	510	320	250	170	70
	33	500	500	320	260	190	60
	34	500	500	320	260	160	60
Week 6	36	500	500	320	250	170	60
	37	500	500	320	260	170	60
	38	500	500	320	260	190	60
	39	510	510	320	250	160	60
	40	500	500	320	260	170	60
	41	500	500	320	260	170	60
Average		**489.31**	**489.31**	**309.58**	**255.83**	**169.44**	**71.11**

In this method, it was found that, BOD decreased with rotating paddles in general between 320, 60 mg/l according to number of impellers. With one rotating impeller, it reached 280,320 mg/l with an average removal ratio 36.7%. The value of BOD varied between 240, 260 mg/l in case of two impellers with an average removal ratio 47.7%. When rotating paddles impellers is increased to three, BOD varied between 140, 190 mg/l with an average removal ratio 65.4%. The minimum value of BOD was 60, 90 mg/l and occurred when the number of impellers was four with an average removal ratio was 85.7%. It is clear from the results that the greater number of impellers has an influence in increasing the BOD removal

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ratio, this occurs as a result of excess dissolved oxygen in the water.

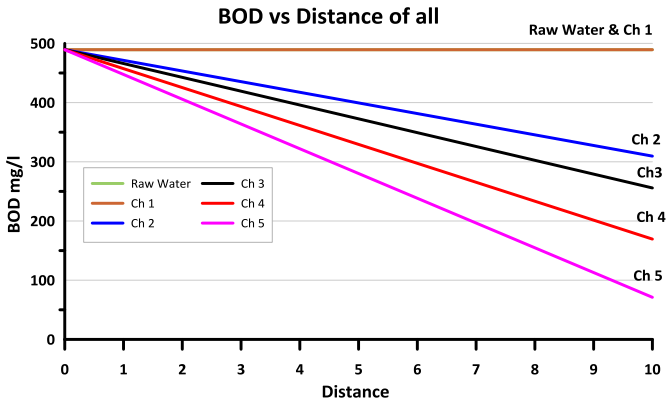

Figure (4) Average BOD Variations with Different Number of Impellers Rotating Paddles

Table (3) COD in Rotating Paddles Experiment

Day		Raw water	Effluent water				
			Ch1	Ch2	Ch3	Ch4	Ch5
Week 1	1	1170	1170	670	470	370	130
	2	1160	1160	660	460	360	130
	3	1170	1170	670	470	370	130
	4	1170	1170	670	470	370	130
	5	1180	1180	680	480	380	130
	6	1170	1170	670	570	370	130
Week 2	8	1180	1180	680	480	380	130
	9	1180	1180	680	490	380	130
	10	1200	1200	700	500	400	130
	11	1220	1220	720	570	370	130
	12	1210	1210	710	480	380	130
	13	1200	1200	700	490	380	130
Week 3	15	1200	1200	700	500	400	130
	16	1190	1190	690	570	370	130
	17	1190	1190	690	480	380	130
	18	1190	1190	690	490	380	130
	19	1190	1190	690	500	400	120
	20	1180	1180	680	570	370	120
Week 4	22	1200	1200	700	480	380	120
	23	1200	1200	700	490	380	120
	24	1200	1200	700	500	400	120
	25	1220	1220	720	570	370	120
	26	1210	1210	710	480	380	120
	27	1200	1200	700	490	380	120
Week 5	29	1200	1200	700	500	400	110
	30	1210	1210	710	570	370	110
	31	1220	1220	720	480	380	110
	32	1220	1220	720	490	380	110
	33	1210	1210	710	500	400	110
	34	1200	1200	700	570	370	110
Week 6	36	1200	1200	700	480	380	110
	37	1210	1210	710	490	380	110
	38	1210	1210	710	500	400	110
	39	1210	1210	710	570	370	110
	40	1210	1210	710	480	380	110
	41	1200	1200	700	490	380	110
Average		**1196.67**	**1196.67**	**696.67**	**504.72**	**380.28**	**121.11**

Table (3) shows the daily results of COD analysis in this experiment. Figure (5) illustrates the average COD variations in the experiment for raw & effluent water in all channels in the run period from March to April 2020.

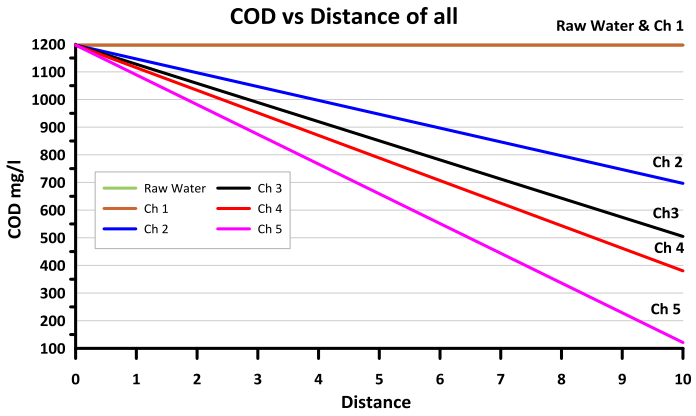

Figure (5) Average COD Variations with Different Number of Impellers Rotating Paddle

From the results obtained, it was found that COD decreased with rotating paddles in general between 720,110 mg/l according to number of impellers. With one rotating impeller, it reached 660,720 mg/l with an average removal ratio 41.8%. The value of COD varied between 460, 570 mg/l in case of two impellers with an average removal ratio 57.8%. When rotating paddles impellers is increased to three, COD varied between 360, 400 mg/l with an average removal ratio 68.2%. The minimum value of COD was 110,130 mg/l and occurred when the number of impellers was four with an average removal ratio was 89.9%. It is clear from the results that the greater number of impellers has an influence in increasing COD removal ratio, this occurs as a result of excess dissolved oxygen in the water.

Table (4) shows the daily results of TSS analysis in this experiment. Figure (6) illustrates the average TSS variations in the experiment for raw & effluent water in all channels in the run period from March to April 2020.

In this method, it was found that TSS decreased with rotating paddles in general between 370,70 mg/l according to number of impellers. With one rotating impeller, it reached 340, 370 mg/l with an average removal ratio 36.1%. The value of TSS varied between 240, 270 mg/l in case of two impellers with an average removal ratio 54.13%. When rotating paddles impellers is increased to three, TSS varied between 190, 220 mg/l with an average removal ratio 63.2%. The minimum value of TSS was 70 mg/l as a constant value and occurred when the number of impellers was four with an average removal ratio was 87.4%. It is clear from the results that the greater number of impellers has an influence in increasing the TSS removal ratio.

Table (5) shows the daily results of Heavy Metals analysis in this experiment. Figures (7) illustrates the average Heavy Metals variations in the experiment for raw & effluent water in all channels in the run period from March to April 2020.

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Table (4) TSS in Rotating Paddles Experiment

Day		Raw water	Effluent water				
			Ch1	Ch2	Ch3	Ch4	Ch5
Week 1	1	550	550	350	250	200	70
	2	550	550	350	250	200	70
	3	540	540	340	240	200	70
	4	560	560	360	260	200	70
	5	560	560	360	260	210	70
	6	560	560	360	260	210	70
Week 2	8	560	560	360	260	210	70
	9	550	550	350	250	200	70
	10	550	550	350	250	200	70
	11	550	550	350	250	200	70
	12	560	560	360	260	210	70
	13	560	560	360	260	210	70
Week 3	15	560	560	360	260	210	70
	16	560	560	360	260	210	70
	17	560	560	360	260	210	70
	18	560	560	360	260	210	70
	19	560	560	360	260	210	70
	20	550	550	350	250	200	70
Week 4	22	550	550	350	250	200	70
	23	550	550	350	250	200	70
	24	550	550	350	250	200	70
	25	560	560	360	260	210	70
	26	550	550	350	250	200	70
	27	540	540	340	240	190	70
Week 5	29	530	530	330	230	190	70
	30	540	540	340	240	190	70
	31	540	540	340	240	190	70
	32	540	540	340	240	190	70
	33	550	550	350	250	200	70
	34	550	550	350	250	200	70
Week 6	36	560	560	360	260	210	70
	37	560	560	360	260	210	70
	38	570	570	370	270	210	70
	39	570	570	370	270	220	70
	40	570	570	370	270	220	70
	41	570	570	370	270	220	70
Average		**554.17**	**554.17**	**354.17**	**254.17**	**204.17**	**70.00**

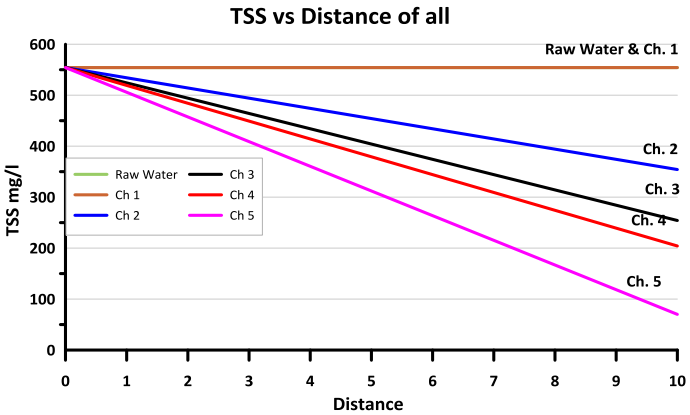

Figure (6) Average TSS Variations with Different Number of Impellers Rotating Paddles

Heavy Metals decreased with rotating paddles in general between 1.8 ,0.4 mg/l according to number of impellers. With one rotating impeller, it reached 0.9,1.4 mg/l with an average removal ratio 14.2%. The value of Heavy Metals varied between 0.8, 1.1 mg/l in case of two impellers with an average removal ratio 27.6%. When rotating paddles impellers is increased to three, Heavy Metals varied between 0.6, 0.9 mg/l with an average removal ratio 44.1%. The minimum value of Heavy Metals was 0.4 mg/l as a constant value and occurred when the number of impellers was four with an average removal ratio was 68.5%. It is clear from the results that the greater number of impellers has an influence in increasing the Heavy Metals removal ratio.

Table (5) Heavy Metals in Rotating Paddles Experiment

Day		Raw water	Effluent water				
			Ch1	Ch2	Ch3	Ch4	Ch5
Week 1	1	1	1	0.9	0.8	0.6	0.4
	2	1	1	0.9	0.8	0.6	0.4
	3	1	1	0.9	0.8	0.6	0.4
	4	1	1	0.9	0.8	0.6	0.4
	5	1.05	1.05	0.95	0.85	0.6	0.4
	6	1.05	1.05	0.95	0.85	0.6	0.4
Week 2	8	1.05	1.05	0.95	0.85	0.6	0.4
	9	1.05	1.05	0.95	0.85	0.6	0.4
	10	1.07	1.07	0.95	0.85	0.6	0.4
	11	1.07	1.07	0.95	0.85	0.6	0.4
	12	1.07	1.07	0.95	0.85	0.6	0.4
	13	1.08	1.08	0.95	0.85	0.6	0.4
Week 3	15	1.1	1.1	1	0.9	0.7	0.4
	16	1.1	1.1	1	0.9	0.7	0.4
	17	1.1	1.1	1	0.9	0.7	0.4
	18	1.2	1.2	1	0.9	0.7	0.4
	19	1.2	1.2	1	0.9	0.7	0.4
	20	1.2	1.2	1	0.9	0.7	0.4
Week 4	22	1.3	1.3	1.1	0.9	0.7	0.4
	23	1.3	1.3	1.1	0.9	0.7	0.4
	24	1.3	1.3	1.1	0.9	0.7	0.4
	25	1.3	1.3	1.1	0.9	0.7	0.4
	26	1.3	1.3	1.1	0.9	0.7	0.4
	27	1.4	1.4	1.1	0.9	0.7	0.4
Week 5	29	1.4	1.4	1.2	1	0.8	0.4
	30	1.4	1.4	1.2	1	0.8	0.4
	31	1.4	1.4	1.2	1	0.8	0.4
	32	1.4	1.4	1.2	1	0.8	0.4
	33	1.5	1.5	1.3	1	0.8	0.4
	34	1.5	1.5	1.3	1	0.8	0.4
Week 6	36	1.5	1.5	1.3	1	0.8	0.4
	37	1.6	1.6	1.3	1	0.8	0.4
	38	1.6	1.6	1.3	1	0.8	0.4
	39	1.8	1.8	1.4	1.1	0.9	0.4
	40	1.8	1.8	1.4	1.1	0.9	0.4
	41	1.7	1.7	1.4	1.1	0.9	0.4
Average		**1.27**	**1.27**	**1.09**	**0.92**	**0.71**	**0.40**

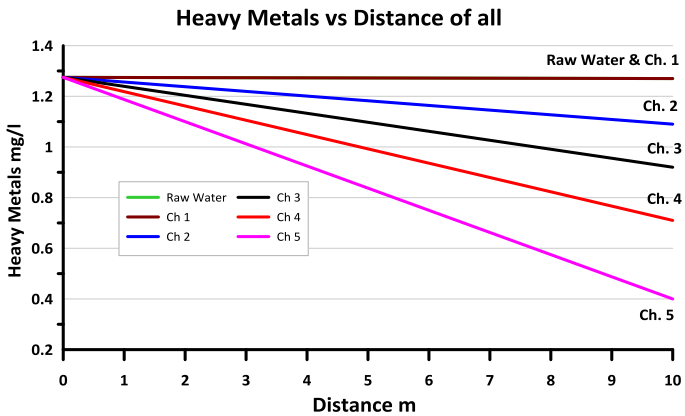

Figure (7) Average Heavy Metals Variations with Different Number of Impellers Rotating Paddles

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In this case which use rotating paddles for treating raw water. The six weeks period of the experiment was from 1st of March to 12th of April 2020 since the effect of weather for bacterial action will be better in summer. The high value of DO in this method was because of rotating paddles acts as an aerated equipment.

V. CONCLUSIONS

The study resulted the following conclusions that help in the treatment of the agricultural drains water for reuse purposes with very cheap and easy operated solution as the rotating paddles.

1. Using Rotating Paddles method increase removal ratio of BOD by 88.4 %, also increase removal ratio of COD by 91%. This is because of when the dissolved oxygen percentage is high as in this method, due to the rotating paddles acts as an aerated equipment for the introduction of oxygen, this leads to an increase in the removal rate of the BOD & COD
2. Using rotating paddles can be applied in agricultural drains to improve quality with low cost in operation and maintenance.
3. Depending on study results a group from serial four paddles could be repeated through the drain stream length to achieve the water enhancement to the suitable level for reuse purposes. This repeat could be with distances varied from 50 meters to 1.0 kilometer depending on the pollution degree and the required water quality for reuse.

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