Effect of Sedimentation on Treated Greywater Through Rotating Biological Contactor

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Abstract:**The aim of this paper was to study the effect of sedimentation on effluent of a pilot scale Rotating Biological Contactor (RBC). The treated greywater was given three hours sedimentation period and samples were analyzed to observe the effect of sedimentations under variousflow rates. Greywater was separated from the black water and collected in the collection tank and then it was pumped to an overhead tank. This tank supplied a regulated continuous flow of greywater into the RBC chamber at the required flow rate ranging between 0.28 to 1.89 l/min. A pilot scale RBC simulator was developed and placed outside a hall of residence at National Center of Excellence in Analytical Chemistry, Sindh University, Jamshoro. The simulator was operated at the rotational speed of discs of 1.7 rpm. The disks were uneven and textured so as to encourage growth of bacteria on them. These discs were immersed about 40 percent in the greywater.The simulator produced effluent of significant quality and was found efficient in removal of BOD5, COD and TSS as 85%, 68% and 95% respectively.**

Keywords- Sedimentation, treatment, rotating biological contactor, greywater

I. INTRODUCTION

Water is life and water scarcity has become the greatest threat to the life on planet earth. It leads to deteriorating water quality and scale up the pollution level. Water scarcity comprises water stress, water shortage and water crisis. Water stress is the difficulty of obtaining sources of fresh water for use during a period of time and may result in further depletion of available water resources. Water shortage may be caused by climatic change, increased pollution, human demand and overuse of water. On the other hand a water crisis is a situation where the available potable water within a region is less than the demand. In a report expressed by [1] that water scarcity can be a result of two systems i.e. physical water scarcity and economic water scarcity. The former is the outcome of inadequate natural water resources to supply and later is a result of poor management of the sufficient available water resources.

As per report [2], 85% of the world population is living in the driest half of the planet earth. Moreover about 783 million people do not have access to clean water and 2.5 billion people do not have access to adequate sanitation. According to [3], in water stressed countries reclaimed water may contribute to the water budget and reduces stress on fresh water resources.

According to [4], Pakistan is one of the most water-stressed countries in the world. Any improvement in water management can be considered as a matter of interest, which will also help to safeguard the sustainability of water for our future generations.

As suggested by[5], the range of demand of water in industrial countries is 100 to 150 liters per capita per day and almost 70 percent of this water is converted to greywater. The application of treated greywater for non-potable use is one of the attractive ideas. It can save almost 30 to 40 percent demand of water if it is used for toilet flushing purpose only. This idea can work only when the treatment system increases the sanitary, environmental and aesthetic conditions of effluent.

As reported by [6], the pre-treatment processes in wastewater are screening, filtration and sedimentation. These steps help in decreasing the clogging in the successive treatment steps.The sedimentation helps in eradicating settle able solids and thus decreases the suspended solids from the greywater. As recommended by [7], thesedimentation process is very effective in removing suspended solids and BOD5, if designed and operated efficiently.In biological treatment processes like activated sludge, trickling filters and rotating biological contactors (RBC) the sedimentation tanks also work as secondary clarifier and removes bio flocs thus reduces the load of suspended solids and other organic fractions.As reported by [8] and [9] the sedimentation process may help to some extent in removing the microbial population.

According to [10]the treated greywater can be used for non-potable purposes such as toilet flushing, gardening, first rinse cycle in washing machines and dishwashers, however, the level of treatment and technology involved would be determined by the reuse application or manner of discharge. As reported by [11],

[12], [5] and [13], there are number of treatment trains which are found in the literature such as reed beds, membrane bio reactor(MBR), rotating biological contactor(RBC) etc.

II. METHODOLOGY

A.Separation of Greywater From Black Water And Sample Collection

A system of pipe network was introduced inthe hall of residence which separates blackwater and greywater. The hall of residence provides maximum accommodation up to 27 bachelor students. The greywater was diverted from baths, showers and lavatories and collected in a collection tank outside the building. A primary sedimentation tank (PST) was constructed to collect this greywater. This tank serves as an equalization tank as well. The wastewater from this tank was further sent to an overhead tank with the help of an electric motor pump and then it was allowed to come in RBC tank under gravity at the required flow rates.The flow rate was controlled with the help of a valve fixed on the inlet pipe near RBC tank. After finishing required hydraulic retention time, the effluent was collected in to the secondary clarifier or secondary sedimentation tank (SST).In this tank the treated greywater was given sedimentation times of three durations. i.e one hour, two hours and three hours. After completing each sedimentation spell the respective samples were syphoned in the sampling bottles and stored in a controlled temperature (4 oC) before dispatching to laboratory for further analysis.

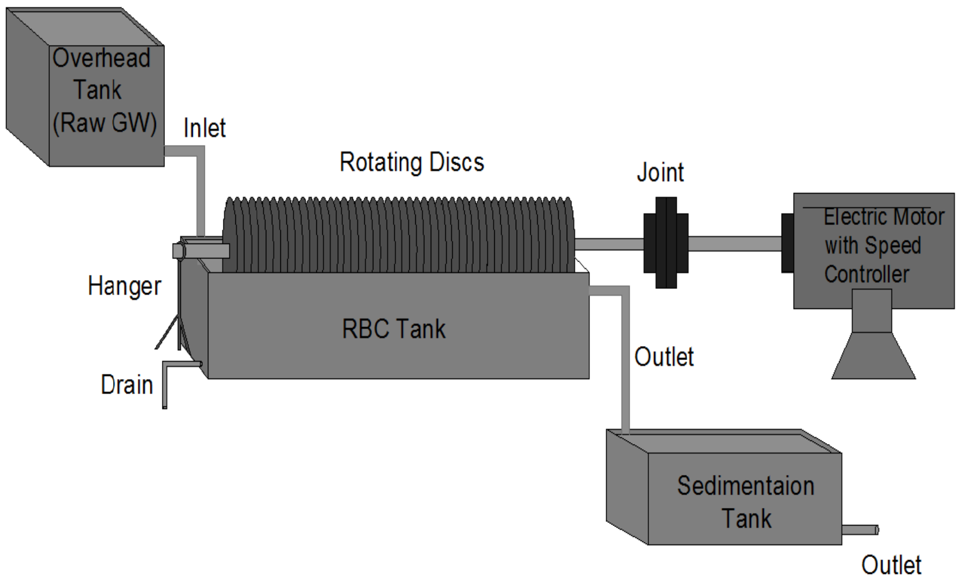

Fig.1. Schematic diagram of RBC system

B.Sample Analysis

The samples were analyzed for pH, Total Suspended Solids(TSS), Biochemical Oxygen Demand (BOD5) and Chemical Oxygen Demand (COD) and Dissolved Oxygen. The pH value was determined by using pH meter(pH-meter 315i/SET), COD, BOD5, DO and TSS were determined by using standard methods namely potassium dichromate (K2Cr2O7 oxidation) closed reflux titrimetric method, Dilution method, Winkler method and gravimetric method respectively [14].

C.Setup and Operating parameters of RBC

The RBC simulator was designed and developed at pilot scale. The capacity of RBC tank was 50 liters and was made-up from organic glass. The discs were also prepared from rough surfacedplastic. Theproportion of holding capacity of tank versus disc area was kept 0.0055 m3 per m2. The discs were submerged up to 40% in the greywater. The rotational speed of discs was controlled with the help of a gear box. The untreated greywater was allowed from overhead tank to the RBC chamber at prescribed flow rate through a valve; and after completing the given detention time in the RBC chamber, the effluent wassiphoned to the secondary clarifier orsecondary settlement tank (SST).The RBC simulator was operated at six flow ratesas presented in Table I while the surface area of discs and their rotational speeds per minute were kept fixed as 9.78 m2 and 1.7 rpm respectively.

TABLE I. Operation of RBC at various flow rates

Flow Rates Category	**A**	**B**	**C**	**D**	**E**	**F**
Flow Rate(Liters/minute)	1.889	0.833	0.555	0.417	0.333	0.278

III. RESULTS AND DISCUSSION

The characterization of raw greywater was performed for more than 25 samples in triplicate and is presented in the Table II. The RBC was operated at aforementioned flow rates and following the completion of retention time the treated greywater was further examined. At this stage the greywater was observed for three sedimentations time periods, i.e. at one hour, two hours and three hours. The efficiency of treatment process is presented in Table III.

TABLE II. Raw greywater characteristics

Parameter	Unit	Mean	Sta.Deviation
BOD_5	mg/l	48.83	14.02
COD	mg/l	182.67	101.92
TSS	mg/l	34.67	24.13
DO	mg/l	3.97	1.66
pH		6.73	0.18

TABLE III. Removal efficiency of treatment process

Parameter	Flow Rate Category	Percent Removal (%) Under Three Sedimentation Time Periods		
		X	Y	Z
BOD5		35	42	52
COD	A	31	40	38
TSS		55	60	58
BOD5		20	40	43
COD	B	42	39	56
TSS		52	55	61
BOD5		40	48	43
COD	C	42	41	47
TSS		60	66	65
BOD5		30	37	41
COD	D	40	35	44
TSS		67	68	79
BOD5		66	66	77
COD	E	42	49	68
TSS		82	92	94
BOD5		81	84	85
COD	F	45	55	55
TSS		84	95	94

The characterization was performed to ascertain the representation of various constituents in greywater. It is concluded that GW constituents shows variation in their concentrations that may be due to consumption of different types of products. The BOD5 of influent was observed as 48±14 mg/l which reflects that the influent was not heavily concentrated with organic fractions, it was rather light greywater. The value of biochemical oxygen demand is relatively lower than the COD values (183±102 mg/l). Moreover the average ratio of BOD5 to COD is measured as 0.27 which is greater than 0.1. It shows that influent is safe to be treated by secondary or biological treatment process. TSS concentration in influent revealsdifferent type of activity being performed by the inhabitants, likewise cleaning or sweeping of rooms, occasionally washing of cloths in bathroom, cleaning of utensils in washbasin etc. The dissolved oxygen level plays an important role in the treatment of wastewater. The level of dissolved oxygen was observed as 3.97±1.66 mgL-1. It is concluded that DO depletes with the increased organic loading and at high temperature. It may be due to fast growth of microbes in hot environment and these microbes uptake the dissolved oxygen during the metabolism process.

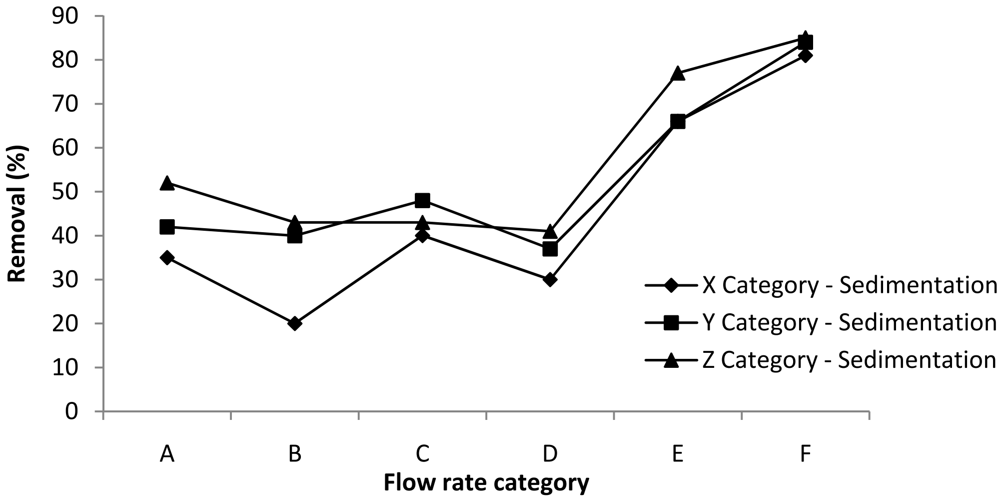

Fig. 2. BOD5removal percentagesat various flow rates and sedimentation periods

Fig. 2 shows the removal percentage of BOD5 at varying flow rates and corresponding three sedimentation time periods i.e X, Y and Z. It was observed that the initial flow rates represented by category A, B, C and D did not show effective removal of BOD5. The removal efficiency ranged 20% to 52% in these flow rates. However significant performance was noticed at flow rates E and F under prescribed sedimentation time periods.This shows that RBC treatment process removes biodegradable organic fractions up to 85% under the conditions of flow rate 0.278 L/min and 3 hours sedimentation time period. With this flow rate the wastewater remains in the system for maximum time of 180 minutes.

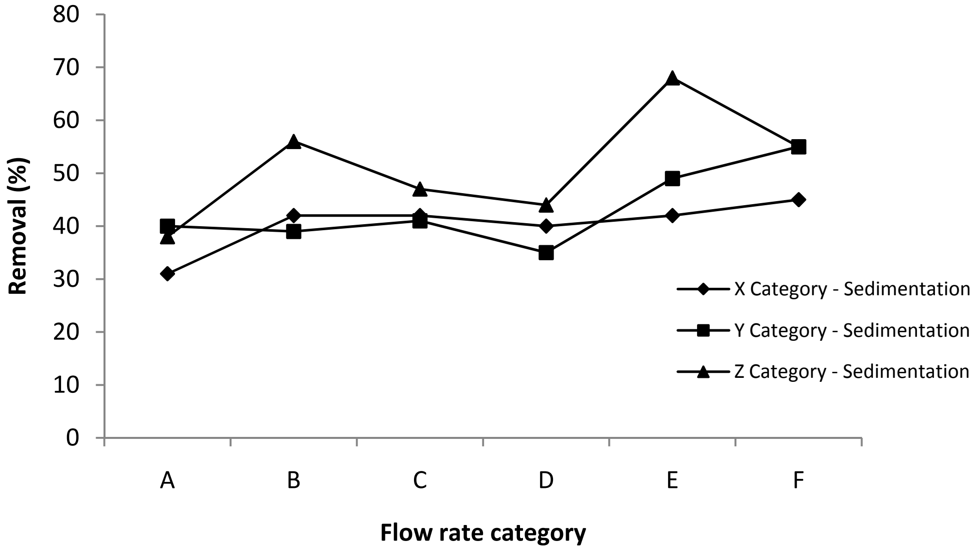

Fig. 3.COD Removal percentage at various flow rates and sedimentation periods

Fig. 3 shows the removal percentage of COD at varying flow rates and three sedimentationstime periods.It was observed that removal of COD ranged 31% to 68%. The maximum removal was observed under flow rates E and F. The effect of sedimentation with regards to COD removal was not very high during the treatment process. This may be due to the presence of non-biodegradable organic matter or slow biodegradable fractions.

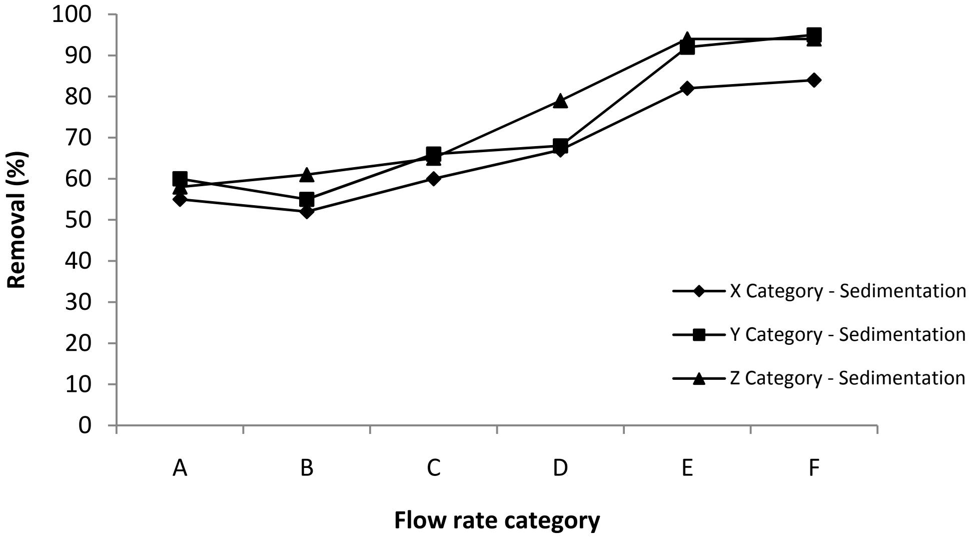

Figure.4 TSS Removal percentage at various flow rates and sedimentation periods

Fig. 4illustrates the removal percentage of TSS. The treatment process showed significant results in term of TSS removal and it raged 54% to 95%. The effective treatment was observed at flow rates E and F with sedimentation time periods Y and Z. This shows that with the help of sedimentation the suspended solids can be reduced to great extent.

IV. CONCLUSION

The treatment of greywater with biological treatment system along with sedimentation process produced significant quality effluent. This can be used for non-potable applications including gardening, toilet flushing, car washing, firefighting and many other purposes. Before applying treated greywater the effluent must be given proper disinfection dose to illuminate microorganisms.

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