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HIGH RATE SETTLER IN BIOLOGICAL SYSTEM FOR OIL AND SOAP WASTE WATER THEATMENT

Sohair I. Abou-Elela*, A. Ashmawy*, H.I. Aly, and H.M. Ahmed**
* Water Pollution Control Department, National Research Centre, Dokki, Cairo, Egypt.
** Sanitary Engineering Department, Faculty of Engineering, Ain Shams University

ABSTRACT

Waste water from an oil and soap company provided the material of this study. The company discharges 31,000 m^3/d of untreated waste water into the Nile River. The waste water was highly contaminated with organic and inorganic pollutants. The end of-pipe treatment scheme was dissolved air floatation aided with/without alum followed by biological degradation. The biological unit was a compact one and it comprises of an aeration tank based on a completely mixed activated sludge process followed by a high rate settler. The unit was operated at two organic loads namely; 1.44 and 2.88 kg $BOD_5/m^3/d$. The results obtained showed that this scheme of treatment produced a high quality effluent amenable for disposal into surface water or/reuse. Also, high rate settler acted as a biological reactor as well as a settler for finally divided organic matter.

KEYWORDS

Waste water- Oil and Soap- Dissolved air flotation- Activated sludge- High rate settler.

INTRODUCTION

While the water demands of Egypt can be met by the Nile's water resources up to the century, the quality of the water is deteriorating rapidly due to the prevailing inappropriate waste water disposal practices. Many parts of the river are not suitable today for potable purposes due to pollution from both domestic and industrial sources. This situation is expected to worsen with the growth in population accompanied by an increase in both industrial and agricultural production. In Rosetta branch of the Nile River, there are many industrial plants discharging their waste water directly into the river without treatment. Among these factories is an industrial complex which produces oil 3rd grade, toilet and laundry soaps, pharmaceutical and industrial glycerine, silicate and fodder. Waste water analysis from different departments showed that the contaminants are every where.

Plant survey and engineering review of the water network indicated that it is difficult at the time beings to separate cooling water from process water. Therefore, all the treatability studies were directed to the end-of pipe effluent.

AIM OF THE STUDY

The aim of this study is to establish and to assess the most affordable and suitable waste water treatment method prior to final disposal into surface water or different reuses.

MATERIAL AND METHODS

Treatment of the end-of-pipe effluent was carried out. The treatment scheme was dissolved air floatation aided with/without alum followed by biological treatment. Two prototype biological treatment units were designed and manufactured for this purpose. The biological unit was based on a completely mixed activated sludge process followed by either a conventional sedimentation tank or a high rate settler at the same operating conditions. (Figures 1 and 2). A schematic diagram of the overall treatment scheme is shown in Figure (3).. The treatment process was carried out in both batch as well as a continuous flow system,. The dissolved air floatation unit used at the optimum operating condition (detention time= 10min. and A/S ratio= 0.008, at pressure of 4 atmosphere) in this study was similar to that used by abou-Elela and Nawar (2). The biological unit was operated at two organic loads namely; 1.44 and 2.88 kg/ $BOD_5/m^3/d$. Also bench scale treatment was carried out to obtain the optimum operating conditions prior to the treatment using a continuous flow system.

Analysis

Analysis of raw waste water and the treated effluents were carried out. All the analysis were performed according to the

American Public Health Association (APHA 1992) methods. The physico-chemical characters covered the following parameters:

pH, total residue at 105°C (TR), total volatile residue at 550°C, total suspended solids at 105°C (TSS), volatile suspended solids at 550°C(V55), settleable solids, turbidity NTU), ammonia-nirtogen (NH_3-N), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), total kjeldahl nitrogen (TKN), total phosphate (T.P), chemical oxygen demand (COD), biological oxygen demand (BOD), soluble biological oxygen demand (BOD sol.) soluble silicate (SiO_2), chlorides (Cl^-), sulfate (SO_42^-), and iron ($Fe3^+$).

RESULTS AND DISCUSSION

In order to maintain a high and consistent effluent quality at least cost it is necessary to optimize the biologiCal process. In recent years, a number of biological processs modification have been developed to enhance the treatment efficiency and to provide a more uniform effluent. In this study waste water from the end-of pipe effluent was subjected to dissolved air floatation followed by completely mixed activated sludge process. The biological unit was provided with a high rate settler.

The results obtained in Figure (4) and Table (1) showed that biological treatment of the floated effluent at an organic load of 1.44 kg $BOD_5/m^3/d$ removed 91% of oil and grease, 98% of BOD_5 and 97% of COD.

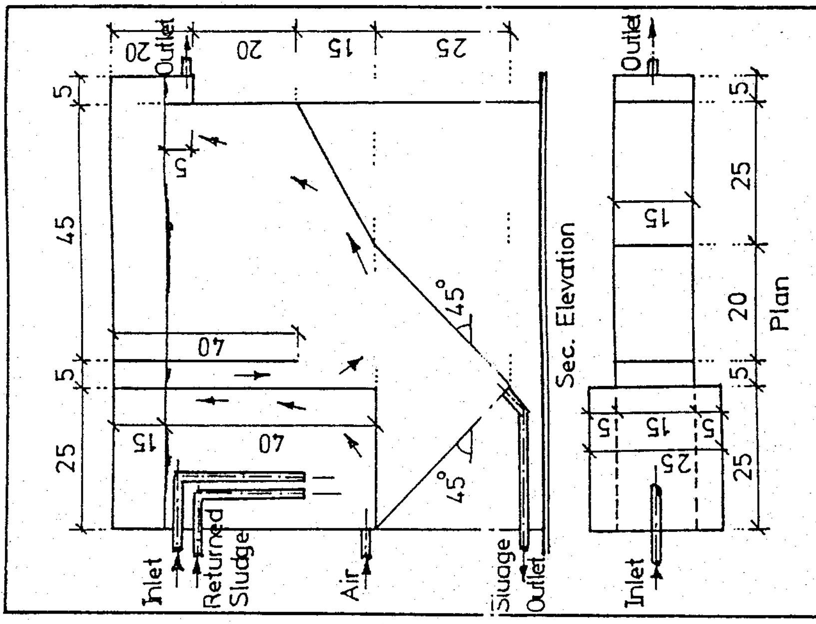


Figure (1). Activated sludge unit with conventional settler.

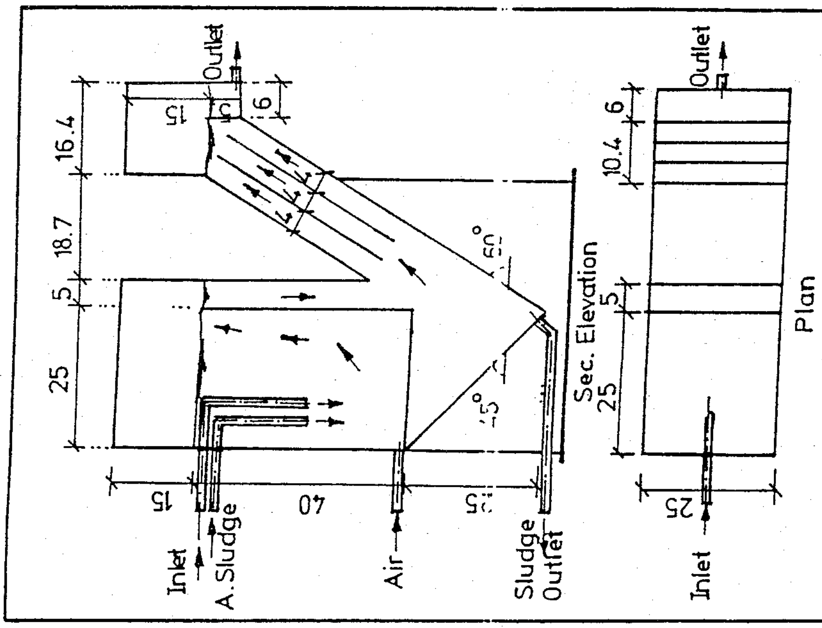


Figure (2). Activated sludge unit with high rate settler.

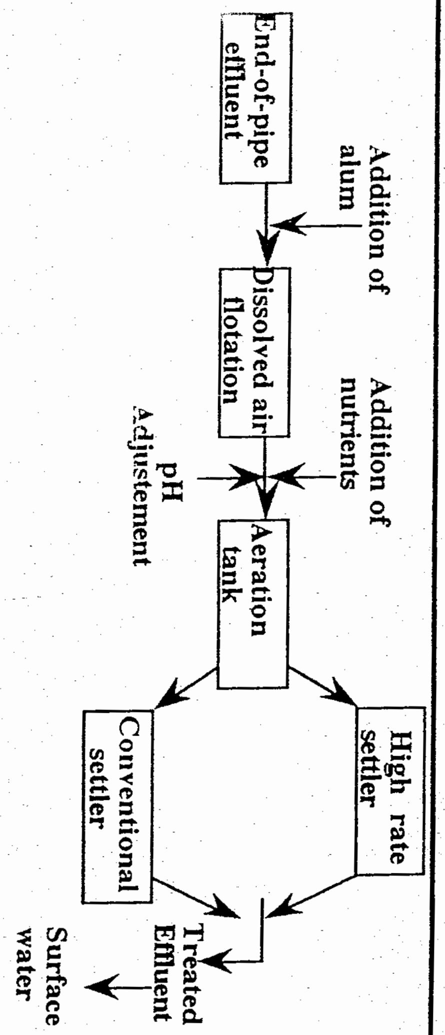


Figure (3) Schematic diagramme of the proposed treatment scheme

Upon increasing the organic load from 1.44 to 2.88 kg $BOD_5/m^3/d$, the treatment efficiency was nearly the same (Figure 4) and Table (2). No dramatic changes in the quality of the effluent occured. The percentage removal values of BOD_5 and COD were decreased by only 1%. These results were confirmed by those obtained by kuan 1973 (3) which showed that when the overflow rate increased to 150% of its normal load under the same conditions, the changes in the efficiency of the circular settler would be from 83.5% to 81.5% which indicated that the high rate settling system is capable of handling overloading without sacrificing too much in turbidity removal SACRIICING efficiency, i.e. less affected by transient loading.

In case of the deterioration of the quality of the final effluent, alum was added with an average dose of 300 mg/L to the raw waste water prior to floatation to breakdown emulsions. The results obtained (Table 3) showed that the applied treatment technique produced a high quality effluent. The removal values of BOD_5,COD and oil and greases reached 99%, 99% and 97.8%, respectively. Further studies were carried out to assess the presence and the use of high rate settler as final treatment step instead of the conventional settler. The results obtained in Figure 5) indicated that the use of high rate settler improved the quality of the treated effluent by 5%. Suspended solids decreased from 28 to 19 mg/L, while the volatile suspended solids were decreased from 21 to 8.5 mg/L. These results indicated that the high rate settler acted as biological reactor as well as a settler for the finally divided organic matters (4,5).

CONCLUSION

As a final conclusion dissolved air floatation followed by biological treatment with a high rate settler proved to be a satisfactory approach for the treatment of oil and soap waste water. The use of high rate settler proved to be more effective than the conventional settler. It acts as a biological reactor as well as a settler for finally divided organic matters. The quality of the treated effluent can be discharged safely into surface water or reused for other purposes.

Table (1) Efficiency of combined treatment via plain dissolved air flotation followed by biological treatment (organic load 1.44 kg $BOD_5/m^3/l$)

Parameters	Units	Raw waste water			Floated effluent				Combined treatment			
		Min	Max	Avg	Min	Max	Avg	%R	Min	Max	Avg	%R
pH		6.7	11.3		6.6	11.0			7.7	7.7		
Turbidity	NTU	115	712	349	43	523	266	54	1.4	19	5.2	98
Chemical oxygen demand	mg O2/L	320	3520	1040	175	2150	764	50	6.0	61	23	97
Biological oxygen demand	mg O2/L	235	1200	535	124	750	380	53	2.4	41	11.8	98
Ammonia	mg N/L	N.D	N.D	N.D	N.D	N.D			N.D	N.D		
Nitrite	mg N/L	N.D	0.06	0.044	N.D	0.06	0.027		0.006	0.213	0.11	
Nitrate	mg N/L	N.D	0.63	0.012	0.413	0.142		0.03	3.25	1.24		
Total kjeldahl nitrogen	mg N/L	2.8	22.4	9.6	1.1	15.7	7.6		N.D	12.3	4.1	
Total phosphate	mg P/L	0.4	20.4	7.1	1.2	13.2	5.4		N.D	9.0	2.8	
Total residue at 105 °C	mg/L	714	3060	1960	1034	1899	1815		603	1419	1143	
Volatile total residue at 550°C	mg/L	169	1541	7173	250	1304	676		94	253	157	
Total suspended solids at 105°C	mg/L	98	1408	403	131	506	435	60	1.2	27	10.6	96
Total volatile suspended solids at 550°C	mg/L	45	1272	271	16	436	146	52	N.D	23	6.4	97
Oil & Grease	mg/L	49.2	813	261	21	296	128	71	6.2	25.6	14	91
Chloride	mg Cl-/L	240	860	526	200	660	504		195	520	351	
Sulfate	mg SO4/L	32	410	140	44	250	128		32	160	109	
Iron	mgFe3+/L	0.8	4.8	1.83	0.2	3.5	1.5		N.D	0.8	0.26	0.26
Soluble silicate	mgSiO2/L	60	240	117	50	150	124		40	90	65.7	

Table (2) Comparison between the biological treatment at the two organic loads .

Parameters	Units	Raw waste water			Organic load of 1.44 kg $BOD_5/m^3/d$				Organic load of 2.88 kg $BOD_5/m^3/d$			
		Min	Max	Avg	Min	Max	Avg	%R	Min	Max	Avg	%R
pH		6.7	8.7		7.0	7.7			7.0	7.9		
Turbidity	NTU	100	500	208	1.9	7.3	3.8	98	3.0	10.1	5.4	97
Chemical oxygen demand	mgO_2/L	320	1250	777	6.0	32	17.5	97	13	50	31	96
Biochemical oxygen demand	mgO_2/L	235	1200	573	3	12	6.9	98.6	5	22	12.7	97
Ammonia	mgN/L	N.D	N.D	N.D	N.D	N.D	N.D		N.D	N.D		
Nitrite	mgN/L	N.D	0.03	0.016	0.03	0.9	0.26		n.d	0.9	0.28	
Nitrate	mgN/L	0.013	0.2	0.08	0.05	7.0	2.63		0.035	7.0	2.5	
Total kjeldahl nitrogen	mgN/L	2.8	22.4	10.6	N.D	9.5	4.5		3.0	13	7.1	
Total phosphate	mgP/L	0.4	9.2	5.5	N.D	9.0	2.7		N.D	9	2.3	
Total residue at 105°C	mg/L	714	2242	1605	603	1491	1117		625	1822	1210	
Volatile total residue at 550°C	mg/L	169	1430	629	94	248	152		122	440	194	
Total suspende solids at 105°C	mg/L	98	594	264	1.2	12	7.7	97	13	34	23.3	88
Total volatile suspended solids at 550°C	mg/L	45	261	129	N.D	10	6	96	2	29	18	81
Oil and Grease	mg/L	62	300	165.3	6.2	16.2	10.7	88.5	8.2	17.2	14.9	84
Chloride	mg Cl^-/L	180	860	442	144	520	295		170	669	361	
Sulfate	mg SO_4/L	32	206	1073	93	160	121		86.4	240	150	
Iron	mg Fe^{3+}/L	0.8	1.7	1.4	N.D	0.8	0.33		0.1	1.0	0.42	
Soluble silicate	$mgSiO_2/L$	60	120	95	45	85	58		48	95	63	

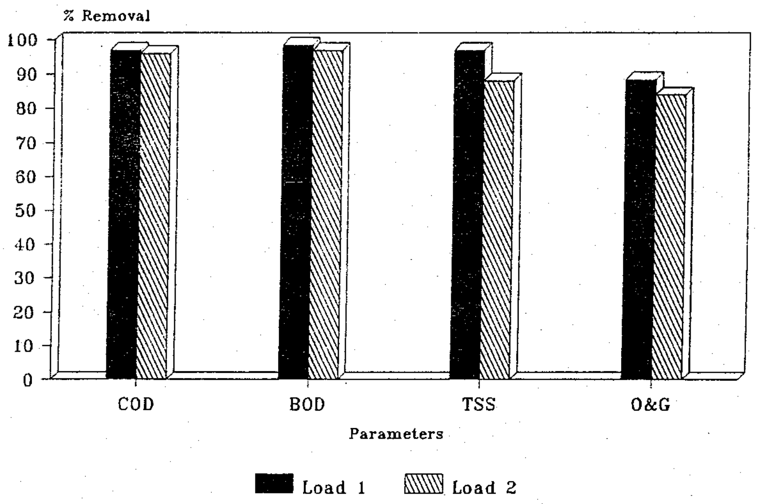
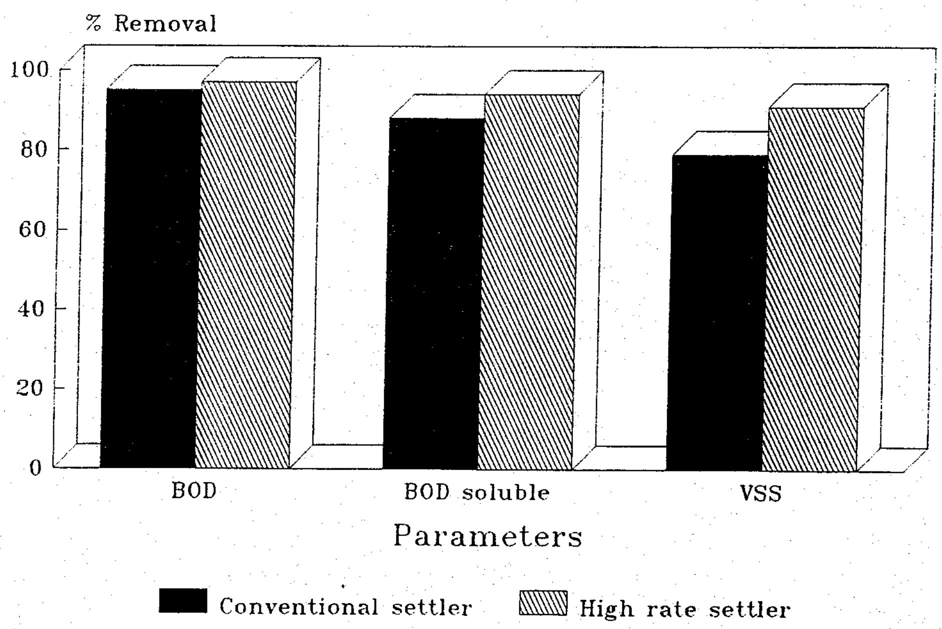


Figure (4): Efficiency of the biological treatment at different organic loads

Load 1 : 1.44 BOD/m^3/d Load 2 : 2.88 BOD/m^3/d



Figure(5) Comparison between the efficiency of conventional and high rate settlers(Organic load= 2.88 kg BOD/m3/d)

Table (3) Efficiency of combined treatment : flotation aided with alum followed by biological treatment

Parameters	Unit	Raw waste water	Chemically treated effluent *		Combined treatment	
		Avg.	Avg.	% R.	Avg.	% R.
pH		8.0	6.3		7.5	
Turbidity	NTU	495	18	97.3	3.5	99
Chemical oxygen demand	mgO_2/L	1832	198	89.3	22	99
Biological oxygen demand	mgO_2/L	1287	152	88	12.6	99
Ammonia	mg N/L	N.D	N.D		N.D	
Nitrite	mg N/L	0.009	0.004		0.47	
Nitrate	mg N/L	0.11	0.07		3.1	
Total kjeldahl nitrogen	mg N/L	12.3	2.5		8.6	
Total phosphate	mg P/L	10	1.5		1.7	
Total residue at 105^oC	mg/L	1677	1055		942	
Total volatile residue at 550^oC	mg/L	783	148		77	
Total dissolved solids at 105^oC	mg/L	1059	1029		944	
Volatile dissolved solids at 550^oC	mg/L	478	134		72	
Total suspended solids at 105^oC	mg/L	618	27	94	9.0	98.5
Volatile suspended solids at 550^oC	mg/L	475	8.0	95	5.0	98
Oil & Grease**	mg/L	700	25	96	15	98
Chloride	mg/L	275	247		249	
Sulfate	$mgSO_4/L$	124	179		195	
Iron	$mgFe3^+/L$	1.6	1.03		0.9	
Soluble Silicate	$mgSiO_2/L$	167	63		46	

* Dose of alum = 300 mg/L

** Oil and grease and all extractable matters by chloroform.

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إستخدام المرسبات ذات المعدل العالى فى المعالجة البيولوجية لمخلفات مصانع الزيوت والصابون

سهير أبو العلا، عزة عشماوى، حمدى إبراهيم على، هانى أحمد

تعتبر صناعة الزيوت والصابون من أكثر الصناعات التى ينجم عنها مخلفات سائلة تحتوى على تركيزات عالية من ملوثات عضوية وغير عضوية ولذلك إهتمت هذه الدراسة بمعالجة مخلف مصنع الزيوت والصابون والذى يلقى بالمخلف الغير معالج إلى نهر النيل مباشرةً.. وقد تم معالجة المخلف النهائى بطريقة التعويم تحت ضغط مع/أو بدون مخثرات متبوعاً بالمعالجة البيولوجية بالحمأة المنشطة.

وقد تم تصنيع وحدة معالجة بيولوجية مندمجة (Compact unit) تحتوى على حوض للتهوية مصحوباً بوحدة ترسيب ذات معدل عالى وقد تم تشغيل الوحدة عند حمل عضوى ١,٤٤ و ٢,٨٨كجم إحتياج أكسجين حيوى/م٣/ يوم وتم تغذية الوحدة بالمخلف المعوم. وقد أوضحت النتائج أن معالجة المخلف بطريقة المعالجة البيولوجية مصحوباً بوحدة ترسيب ذات معدل عالى أعطت نوعية جيدة من المخلف تسمح بإلقائها على المسطحات المائية.