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Evaluation of the Performance of the Aerated Grit Chambers Under No Maintenance Condition

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ABSTRACT

This paper falls into the studying of an aerated grit chamber (AGCs) within the Al-Rustamyah sewage treatment plant-third extension (50 km south of Baghdad). This treatment plant is suffering some troubles associated with inefficient grit chambers due to lack of continuous maintenance resulting in abnormal grit deposits in the subsequent units of the treatment plant, especially digesters tanks. Field tests on these AGCs were conducted for evaluating their operating performance and their efficiency of removing TSS and oil and grease content during 30 days. Samples were taken from the inlet and outlet of each AGCs every 48 hour and were analyzed. The performance of these AGCs was also re-evaluated again by plotting the velocity distribution across a chosen chamber, at four sections perpendicular to the flow in the AGC. Certain operating problems were observed in the existing AGCs as a result of the experiments.

Keywords : Aerated Grit Chambers , sewage treatment , TSS and grease.

تقييم اداء احواض ترسيب الرمال الموجودة في حال عدم اجراء الصيانة

الخلاصة

يخص هذا البحث دراسة أحواض إزالة الرمال المهواة ضمن محطة الرستمية لمعالجة مياه الفضلات المجاري – التوسع الثالث و الواقعة 50 كم جنوبي بغداد . إن هذه المحطة عانت من عدة مشاكل تشغيلية تتعلق بعدم كفائة التشغيل لهذه الأحواض .و هذه المشاكل هي نتيجة عدم و تاخر الصيانة الدورية مما ادى الى تراكم كبير من رمال النهر المنجرفهمع مياه الصرف الصحي . أجريت فحوصات حقلية لمدة 30 يوما لدراسة الكفائة التشغيلية لهذة الاحواض . وتم أخذ نماذج من مدخل و مخرج كل حوض من داخل هذه الأحواض و تم إيجاد محتوى المواد الصلبة الكلية و محتوى الدهون لكل عينة . كذلك تم دراسة كفاءة هذه الأحواض بواسطة دراسة توزيع سرعة الجريان داخل احد الأحواض ولاربع من المقاطع العرضية على طول الحوض . تم تثبيت الكثير من العيوب و على ضوئها تم التوصل الى نتائج و توصيات مهمة بهذا الصدد.

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INTRODUCTION

With increasing mechanization of wastewater treatment plants, greater consideration is given to equipment protection. As a result, grit removal facilities are commonly provided at all treatment plants. It is necessary to remove grit from the raw sewage in the treatment plants in order to : (1) protect moving mechanical equipment and pumps from unnecessary wear and abrasion, (2) prevent cementing effects on the bottom of the sludge digesterand primary sedimentation tanks, (3) reduce accumulation of inert material in aeration basins and sludge digesters which would result in loss of usable volume.(1)

Grit is selectively removed from the organics by : (1) a velocity constant grit chambers or in (2) an aerated type grit chambers. Both unit operations are commonly used.

The objective of this work was inspection and evaluation of the existing aerated grit chambers within Al-Rustamyah sewage treatment plant-third extension (Baghdad/Iraq) under that condition of no maintenance which affected in collapsing of theirs longitudinal baffle coupled with the absence of aeration.

Aerated Grit Chambers

Aerated grit chambers (AGCs) are usually designed to provide detention periods of about (3.0 to 5.0) minutes at a maximum rate of flow. The cross section of the tank is similar to that provided for spiral circulation in activated sludge aeration tanks(2) except that hopper about (3 ft) deep with steeply sloped sides is located along one sides of the tank under the air diffusers. The diffusers are located about (18 inch or 2 ft) above the removal plane of the bottom. The basic design data for the AGCs at Al-Rustamyah S.T.P. designed by (Ruthna Inc.) were as follows(3):

No. of the AGCs	6
Each :	
Working length of the chamber	51.00 m
Effective depth of the chamber	6.0 m
Effective width of the chamber	2.8 m
Effective width of the scum collector	3.2 m
Surface area, detritor	140 m^2
Surface area, scum collector	160 m^2
Working Capacity of AGCs	641 m^3
Retention time at peak flow	5.0 min.
Type of diffusers	Nozzles

Typical cross sections of these AGCs are shown in Fig.(1).

The Function of Vertical Baffles within the AGCs

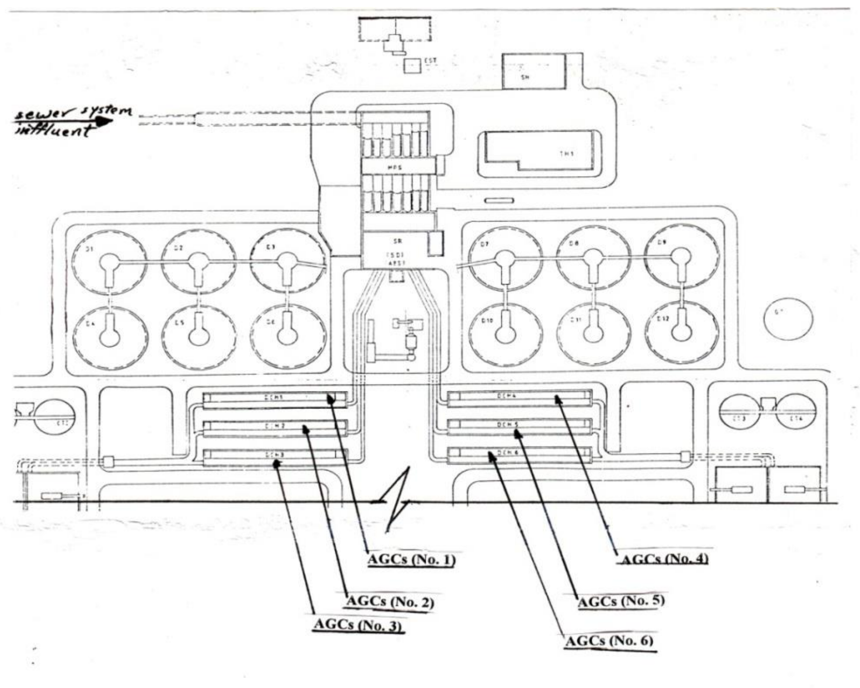
In 1967, Albrecht (4) described a satisfactory method for hydraulic control of conventional AGCs. The installation of a vertical baffle agrees with the requirements of hydraulic controlling in the region of the collector. It is noted that the vertical baffle enable concentrations of the air lift pumping action in the region of the collector. The resultant circulation patterns is illustrated in Fig.(2).

Description of the Case Study Problem

As in the design, the AGCs according to the number of screen lines are-also six units-the next step of treatment. In principle each chamber of a (51.5) m length and of a total width (6.0) m is divided into degritting, a scum changing and a takeoff section with compressed air brought by means of nozzles produced a water circulation which guarantees a minimum velocity of (20) cm/sec. This enable the settling of sand in the scum chamber and they are divided with a longitudinal baffle (made of high quality wood) so that the transversal water circulation also is effective in the scum removal chamber.

The collapsing of the longitudinal baffle interacted with some failures in screening units and aeration equipments (due to insufficient maintenance for the AGCs), all of these caused the case study problem. Fig.(3) is a sketch of an AGC, and the arrows indicate the circulation patterns just before the occurrence of the problem under study. This location was actually noted as seen visually in a dewatered AGC plate (1) through plate (4).

Abnormal accumulations of sand, grit, plastic, etc., insufficient screening of incoming sewage from screen units gave rise to the case study problem at hand, which resulted in the failure of the installed vertical baffle. The grit mounds up and thus clogging the opening under the vertical baffle. Accumulation of grit piles up causing an abnormal lateral load upon the vertical baffle, columns, causing them to collapse.



Location of AGCs at Al-Rustamyah S. T. P.

Figure.(1) Locations of AGC's at Al-Rustamay Sewage Treatment Plant

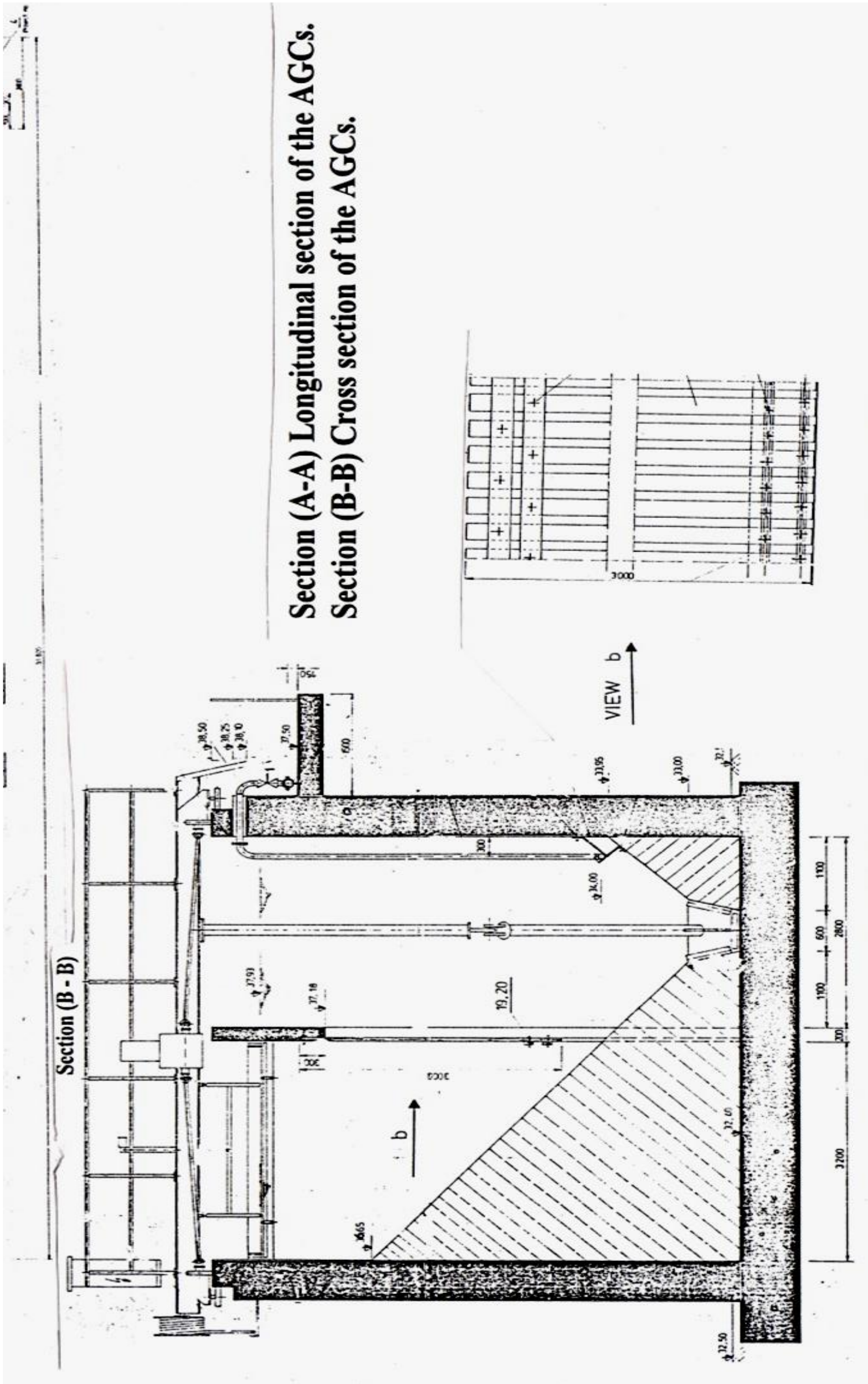


Figure.(2) Cross sections of the AGCs.

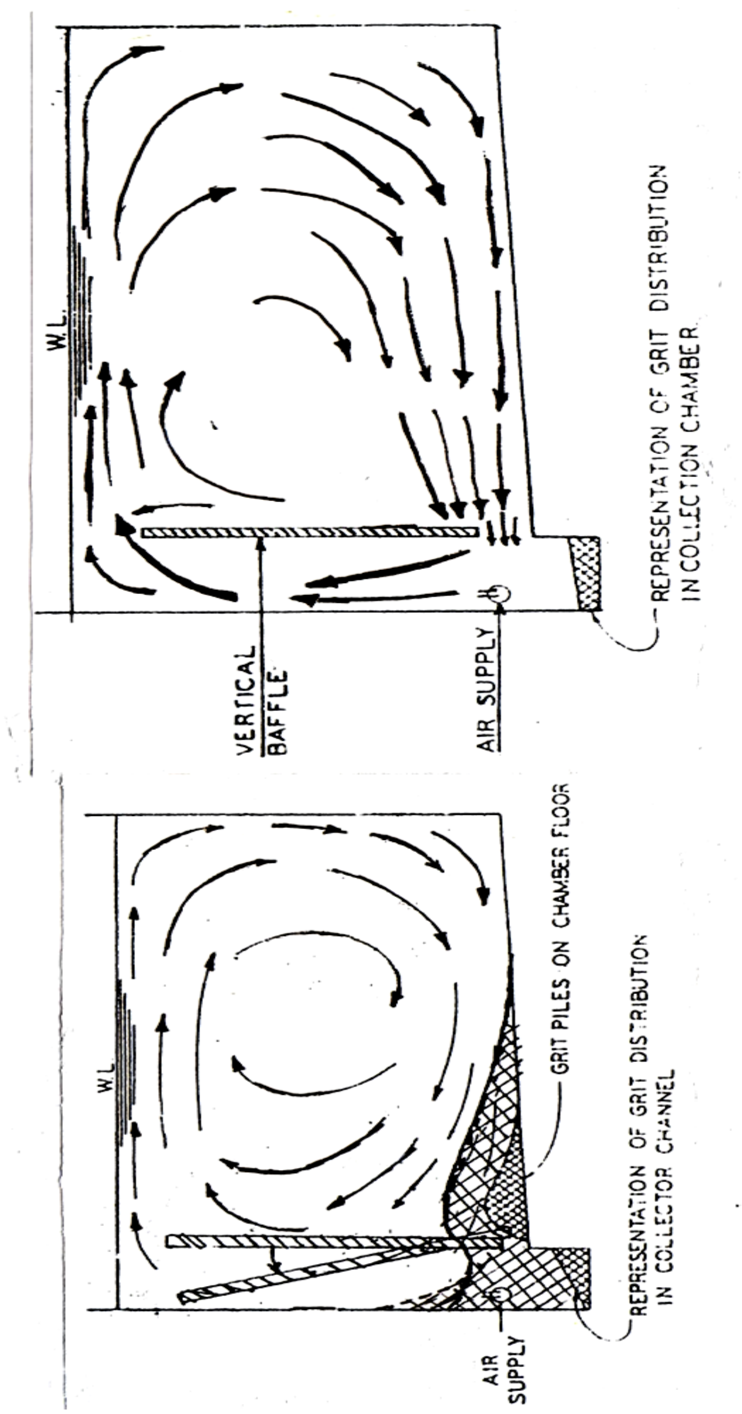


Figure.(3) The resultant Circulation Pattern in AGCs.

Plate (1) Accumulation of Grit Mounds at the Outlet Zone of a Dewatered AGC.

Plate (2) A dewatered AGC "location of Grit Mounds

Plate (3) Scum Accumulation at the Outlet Zone of a Working AGC.

Plate (4) A dewatered AGC "Aeration Equipment's Clogging".

Experiment Works

As the determination of TSS and grease, and their fluctuations during the operation of AGCs, are parameters commonly used for evaluating the performance of AGCs [5], therefore the site experimental work on the AGCs conducted was included (TSS and oil and grease) content of the influent and effluent sewage to the four of the operating AGCs.

During the period of the investigation, samples of the sewage were taken each (48 hours) from the inlet and outlet of each of four operating AGCs. These samples were analyzed for TSS and oil and grease content in accordance with standard methods of examination of water and wastewater; 5th edition 1985 (209, C, PP.96) and (209, B, PP.83), respectively.[6]

The performance of the AGCs were also evaluated by obtaining velocity distribution for four perpendicular sections across one chosen AGC, with a specially developed velocity meter. The site of section (one) was at the beginning of the chamber, section (two) was at the beginning of the longitudinal baffle joint, section (three) was at the middle of the chamber, and section (four) was nearly at the end of the AGC.

The velocity distribution of each section was determined from point velocities measurements. Each section was divided into 5 bays, each of a one meter distance from the other, Typical point velocities, V in (cm/sec) was measured in the vertical dimension each (0.25) m from the surface of the sewage. This value was divided by the theoretical horizontal velocity, $\overline{V}$ of (20) cm/sec assumed to be the average velocity for the whole section and along the chamber. The ratio ($V/\overline{V}$) for each point in the four sections and throughout the four sections, was computed to give a non dimensional relative velocities. The values of ($V/\overline{V}$) were used to develop contours of equal velocity or isovels for each of the four sections.

Results and Discussions:

During the period of these tests, the AGC (No. 1) and AGC (No. 4) were out of service. Therefore, the samples were collected from the inlet and the outlet of the rest AGCs (No. 2, 3, 5 and 6), and analyzed for Tss and grease content. The values of removal efficiencies were determined according to the following equations[2] :

$$R_{T_{ss}}, \% = \left[1 - \frac{T_{ss}(out)}{T_{ss}(in)}\right] \times 100 \qquad \cdots\cdots(1)$$

$$R_{GREASE}, \% = \left[1 - \frac{GREASE(out)}{GREASET_{ss}(in)}\right] \times 100 \qquad \cdots\cdots(2)$$

The Parameters, TSS and oil and grease for each of the four AGCs were measured. The variations of the above parameters are shown in Table (1) and Table (2). Variations of the removal efficiency of TSS and grease for the AGCs are presented in Table (3) and Table (4), respectively.

After the sewage effluent AGCs, from the concentration values of TSS and grease were slightly decreased as shown in Table (1) and Table (2). The effluent concentration of TSS from the four AGCs were found to be higher than that permitted according to literature [(7)], which state that the effluent TSS from the sedimentation units must be between (80-100) mg/l.

From Fig. (4) and Fig. (5), it could be observed that for the four AGCs, the removal efficiency of Tss ranged between (4.005-8.404)% as shown in Table (3). It is clear that this was due to the presence of high accumulation of grit inside the AGCs, which almost tended to re-suspended.

From Table (4), it could be observed that the removal efficiency of grease ranged between (3.840-5.890)%. These low values were due to the fact that the skimmers which sweep the accumulated floatable matter over the sewage surface were out of service for along periods of time causing unpermitted accumulations especially at the corners of the AGCs and near the outlet zone of the AGCs.

Inspection of the values of the coefficient of variation (C_v) in Table (1), Table (2) reveals an interesting finding regarding the performance of all AGCs in removing TSS and grease. The C_v of the influent and effluent concentration of TSS for all AGCs were found to be equivalent, or sometimes the C_v of the effluent TSS was higher than the influent.

Statically speaking, this indicates that there is a serious short circuiting with large portion of the tank volume being dead. It, also, indicates that scouring in all AGCs was fully developed. As far as the results of the contents of grease for influent and effluent stream lines of the AGCs, the problem was more amplified large values of the C_v of the influent grease content indicated that there was a tremendous variation in grease content of the influent stream.

Large values of the C_v of the influent grease content indicated that there was a tremendous variation in grease content of the influent stream originating into the plant originating in the city. The corresponding high value of the C_v of the grease content of the effluent stream from each AGC indicated that short circuiting and carryover of the grease slugs were dominate.

All the above point out to the fact that all AGCs have bad performance which is thought to be the result of poor maintenance and management.

Table (1) Mean Values and Standard Deviations of Tss Results

Item	Influent TSS to the AGC, mg / l				Effluent from the AGC, mg / l			
	Observed limit	Mean , ū	σ	C_V	Observed limit	Mean , ū	σ	C_V
AGC No.2	81-601	204.7	137.97	0.674	75-100	194.16	134.16	0.6898
AGC No.3	79-590	202.66	135.25	0.667	72-568	191.41	121.35	0.6339
AGC No.5	78-600	198.44	135.25	0.682	70-576	179.3	129.57	0.7226
AGC No.6	79-594	200.71	135.59	0.676	73-581	183.6	130.97	0.713

Table (2) Mean Values and Standard Deviations of Grease Results.

Item	**Grease influent to the AGC, mg / l**				**Grease effluent form AGC, mg / l**			
	Observed limit	Mean , ū	σ	C_V	**Observed limit**	Mean , ū	σ	C_V
AGC No.2	34-1666	324.49	508.59	1.567	33-1595	309.77	481.65	1.5548
AGC No.3	102-1818	466.74	567.54	1.216	99-1728	443.76	543.65	1.225
AGC No.5	98-1942	297.47	617.91	2.077	95-1876	283.75	595.5	2.098
AGC No.6	106-1768	315.57	457.44	1.449	97-1715	290.29	440.27	1.5167

Table (3) Mean Values and Standard Deviation of TSS Removal

Item	Removed Efficiency of TSS, %			
	Observed limit	Mean , ū	σ	C_V
AGC No.2	1.33-7.4100	4.107	1.962	0.47777
AGC No.3	0.3205-23.218	4.005	4.972	1.24
AGC No.5	2.5381-18.7215	8.404	4.670	0.555
AGC No.6	2.1886-18.0556	7.059	4.529	0.641

Table (4) Mean Value and Standard Deviation of Grease Removal

Item	**Removed Efficiency of Grease, %**			
	Observed limit	**Mean, $\overline{X}$**	**S**	**C_V**
AGC No.2	0.7692-6.9048	4.1295	1.6084	0.389
AGC No.3	0.9934-7.0796	4.3937	1.8498	0.421
AGC No.5	0.9259-11.2149	3.8416	2.6856	0.699
AGC No.6	1.8519-15.2439	5.890	3.9798	0.675

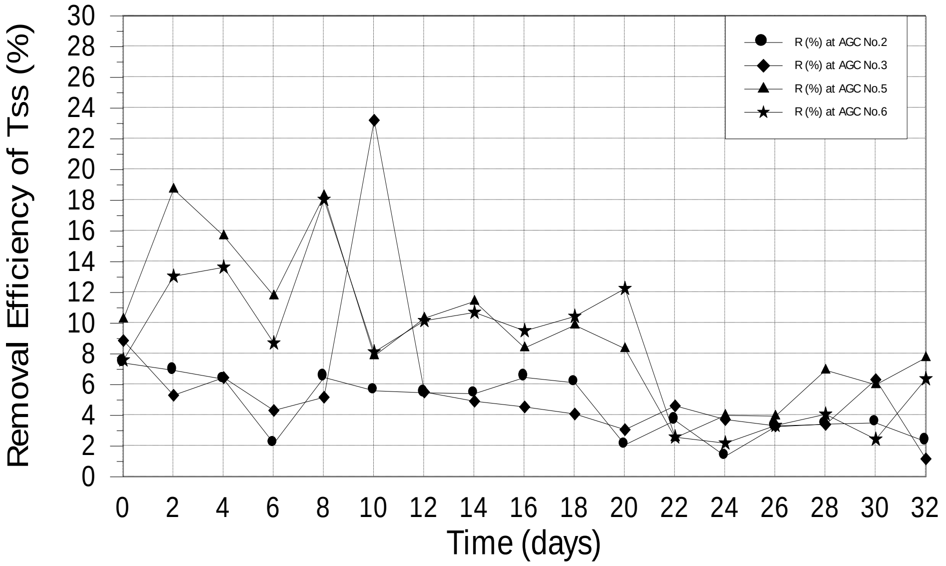


Figure. (4) The Removal Efficiency of Tss across AGC (No. 2, 3, 5 and 6) during 18 Aug-19 Sep.

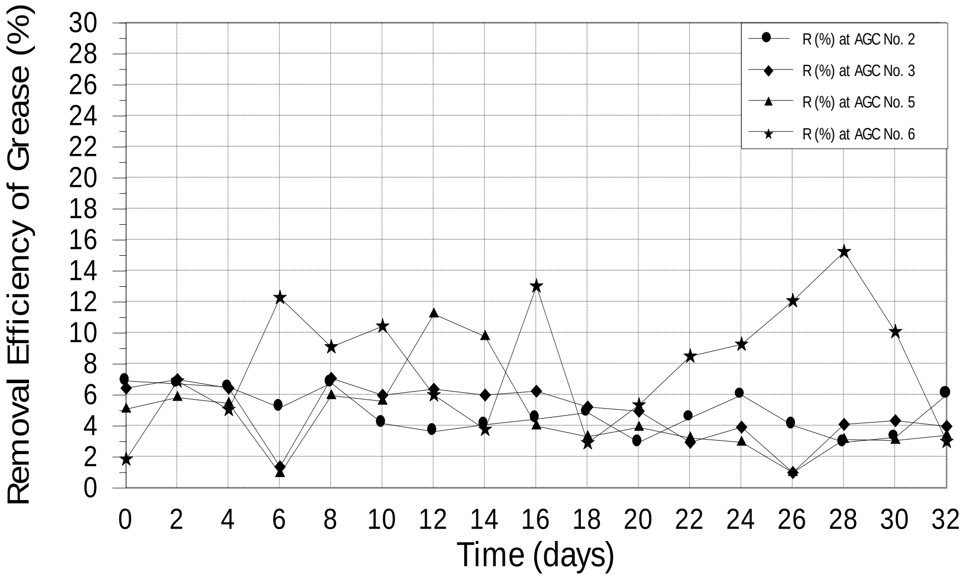


Figure.(5) The Removal Efficiency of Grease across AGC (No. 2, 3, 5 and 6) during 18 Aug-19 Sep.

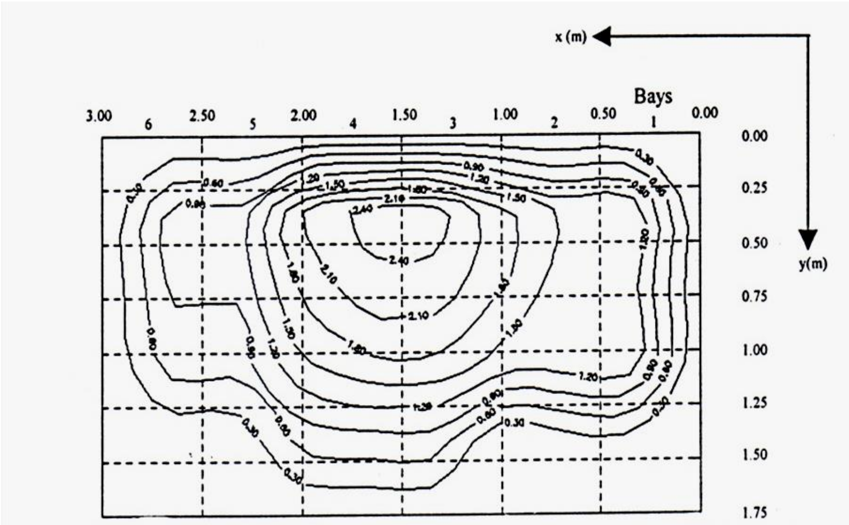


Figure.(6) Velocity Distribution across the section (1) of the AGC(No.6)

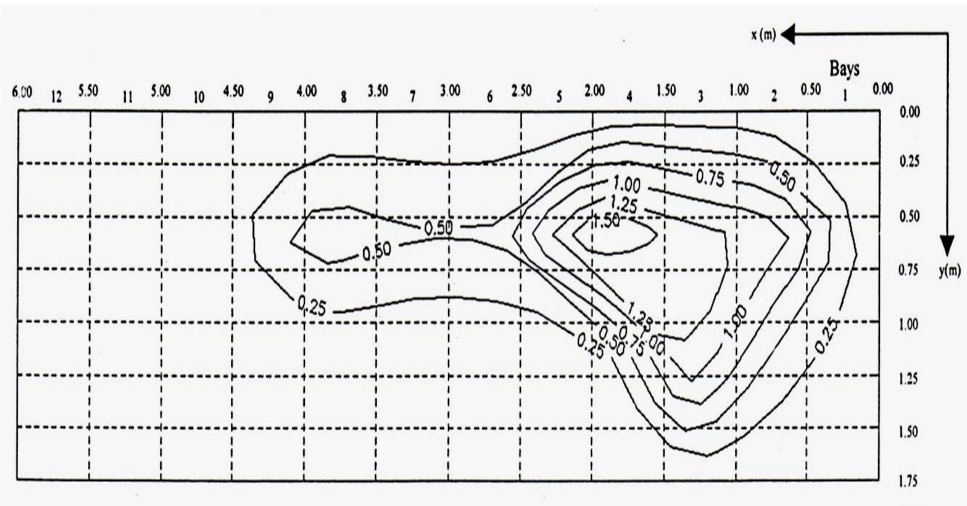


Figure.(7) Velocity Distribution across the section (2) of the AGC(No.6)

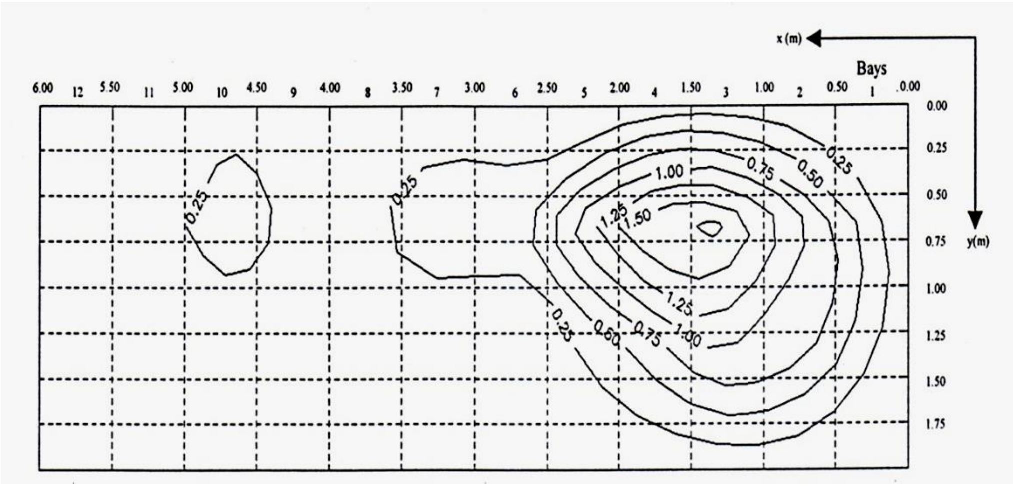


Figure.(8) Velocity Distribution across the section (3) of the AGC(No.6).

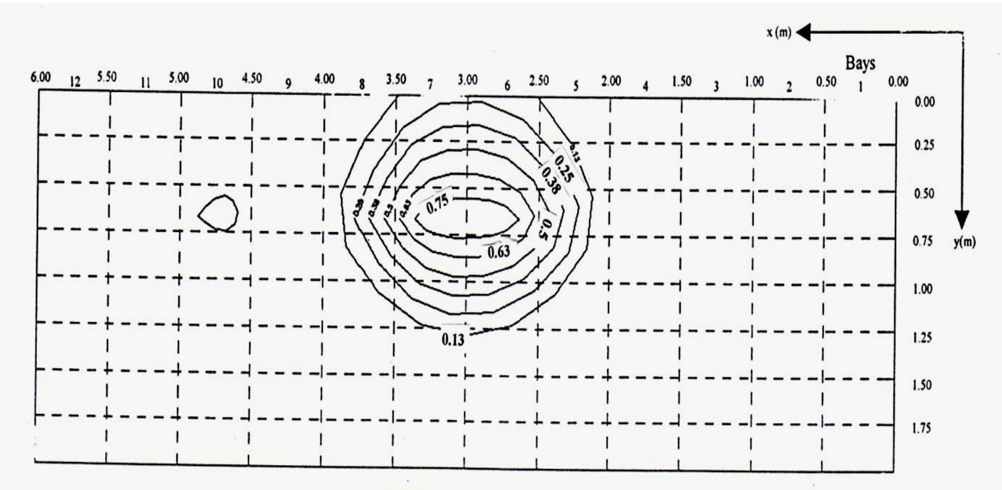


Figure.(9) Velocity Distribution across the section (4) of the AGC(No.6)

Results and Discussions of Velocity Distribution Tests

The AGC (No.6) was chosen for the purpose of evaluating its operation characteristics. The selection of this AGC was based on the fact that it was the only one that has its scraper working and could move along the chamber length. The results of this test were fed into and analyzed by the computer program software (surfer) to obtain the contour lines of the relative equivalent velocity values $V/\overline{V}$. The results of the computer graphics are shown in Fig.(6) through Fig. (9).

At section (1), in Fig.(6), it could be observed that, there is only one large cell of high-velocity located in the top parts of bays 3 and 4 with some uniform velocity region near the surface due to the fact that this section is located at the inlet zone of the AGC (No.6). The magnitude in this high-velocity cell became smaller and it increased in size and spread to include parts of bays (3, 4, and 5) of section (2) as shown in Fig.(7). Fig.(7) shows that at section (2) there is a small area or cell of high-velocity in bay (4). A second cell with a smaller velocity is located in bays (7 and 8).At section (3), Fig.(8), there is a small region of high velocity in bays (3 and 4) with a smaller cell of low velocity located in bay (10).At section (4), Fig.(9), there is only one small high velocity area in bays (6, 7 and 8). This high velocity region has enlarged in area with reduction in magnitude when compared with sections (2) and (3).In general, it could be observed that there were large areas of dead spaces for the three sections especially in bays (10, 11, and 12). These bays are located in the region of the degritter where the longitudinal baffle collapsed and were due to absence of aeration along the tank length that could have provided a helical flow of the fluid body. In general, for the whole four sections, it could be observed that the depths of the flow ranged between (1.75-2.00) m, which meant that the accumulation of grit level inside the tank reached (4.00-4.25) m. This accumulation should not be permitted at all, because it decreases the grit removal and tends to resuspend settled solids in the bottom of the chamber. It is worth mentioning that the ill-distribution of the velocity currents of the flow is the result of the bad maintenance which is also the result of the stoppage of the operation of the grit removing system. Had the grit removing system been working, in the opinion of the writer, all these problems could have been avoided. No collapsing of the longitudinal baffle and no accumulation of grit could have been possible if the degritting system was operating. One important fact which was observed by the writer, was the septicity problems which was the results of the failure of the above mentioned degritting system coupled with the non-operating aeration system. In the writer opinion, septicity problem could be alleviated if the aeration systems, degritting systems, and longitudinal baffles are reinstalled as designed.

CONCLUSIONS

Certain operating problems were observed in the existing AGC_s installations. These problems included:-

1. Higher concentrations of TSS discharged from the AGC_s, than the permitted limit.
2. For the four AGC_s (No.2, 3, 5, and 6), the removal efficiency of TSS was limited between (4.005-8.404)%, while the removal efficiency of grease was limited between (3.84-5.89)%.
3. The flow was poorly distributed along the AGC (No.6) and this resulted in large areas of dead spaces, high accumulation of scum at the outlet zone, high velocity region near the flow surface, and high accumulation of the settled grit inside the chamber.

REFERENCES

[1]Qasim, Sayed R., 1985 “Wastewatser Treatment Plants”, CBS College Publishing Ltd., Japan.

[2] Metcalf & Eddy Inc.,, 1979 “Wastewater Engineering, Collection, Treatment, Disposal”, McGraw Hill Ltd, New York.

[3] Haiste and Partners , 1981 “Greater Baghdad Sewage Study, Preliminary Report”.

[4] Albrecht, A. E., “Aerated Grit Chamber Operation and Design”, Water & Sewage Works, Vol.114, No.9, Sept. 1967.

[5] Sawyer, C. N., and McCarty, P. L., ., 1978 “Chemistry for Environmental Engineering”; Third edition, McGraw-Hill. Inc.

[6] APHA, AWWA, WPCF, 1985 “Standard Methods for the Examination of Water and Wastewater”, Sixteenth edition, Washington D.C.

[7] ASCE-Manual and Reports on Engineering Practice “Wastewater Treatment Plant Design”, No.36, (WPCF-Manual of Practice No.8); 1977.