EVALUATION OF THE PERFORMANCE OF THE DORA REFINERY WASTEWATER TREATMENT PLANT

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ABSTRACT

Oil refineries are major contributors to local environmental problems .The main pollutants are oil , dissolved components , spent acids , suspended solids, sludge . Technically it is possible to remove all these pollutants by Physical , chemical and biological means .Oil is initially removed in the (API) separators , by skimming, while the heavy particles by scrapping . Further removal of discrete particles is done by gravity settlement in the primary settlement tank .The remaining suspended matter is removed by chemicals , that are added in the flocculation tank , while further flocs are removed in the air flotation tank . The biological treatment follows to remove the biological pollutants , usually followed by secondary settlement to reduce the flux of suspended particles carried with the effluent water. This thesis deals with the Dora refinery wastewater treatment plant , its present performance in comparison with the designed treatment performance and its final effluents compared with the Iraqi discharged water quality limitations .In order to identify the characteristics of the refinery effluents and to evaluate the performance of the refinery wastewater treatment plant , wastewater from different treatment stages were analyzed for various physical and chemical parameters . Using these parameters as the criteria of performance , comparisons were made between the actual and the designed performance for various potential pollutants. The sampling was conducted during 6 months from May to October 2006 , with two samples in each month for each of the units, one before , and one after.The results showed that the wastewater treatment plant in Al-Dora Refinery performed significantly, where high removal efficiencies , were obtained. For T.S.S , Oil , COD , BOD , Sulfide and Phenol which were 95% , 88% , 86% , 81% , 85% and 97% respectively . And the plant was not very efficient in NH_3 , SO_4 and PO_4 removal .

الخلاصة

ان المصافي تعتبر عالميا مساهم رئيسي في مشاكل البيئة الموقعية . اهم الملوثات الناتجة من المصافي والتي تنصرف مع المياه هي النفط ومركباته ,المواد المذابة والعالقة , الحوامض , الحمأة وغيرها . فنيا بالامكان ازالتها جميعا باساليب فيزياوية , كيمياوية وبايلوجية .حيث يتم ازالة النفط اولا في محطة المعالجة في خزانات خاصة للعزل وذلك بترك المياه فيها وقشط النفط الطافي على السطح وكذلك قشط المواد المترسبة في القعر . وتكون عملية الفصل في هذه الخزانات بفعل الجاذبية الارضية .

تلي هذه المرحلة عملية فصل للمواد العالقة وذلك بخلط مواد كيمياوية مخثرة مع المياه في خزانات التخثير والدمج ومن ثم يتم تطويف المواد العالقة والمتكتلة في خزانات التطويف حيث يتم قشطها من السطح ومن قعر الخزان باستخدام القاشطات الخاصة لذلك. تتبع هذه العمليات عملية المعالجة البايلوجية, والتي يتم فيها معالجة المواد الذائبة بفعل الاحياء المجهرية (البكتريا) ومن ثم يتم فصل هذه الملوثات وترسيبها في احواض الترسيب النهائي لفصل ما تبقى من المواد العالقة والمتجمعة والاحياء الحية المجهرية لتقليل جريانها مع المواد المنصرفة الى النهر.
المعالجة البايلوجية في مصفى الدورة تستخدم التهوية الممتدة ووحدات الحمأة المنشطة. يتوفر في وحدات المشروع الاجهزة اللازمة للقشط والخلط والتهوية, وأحياء مجهرية حية تتغذى على الملوثات المجهرية.
تستخدم هذه الدراسة أسلوب البحث والتحليل الاحصائي للبيانات المستحصلة من قراءات التحاليل الكيميائية للنماذج المأخوذة من مختلف المواقع في محطة المعالجة. وطريقة اخذ النماذج المتبعة كانت نموذج قبل وبعد كل وحدة من وحدات محطة المعالجة ولمدة ستة اشهر وللفترة من ايار وحتى تشرين الاول من عام 2006 وبواقع فحصين كل شهر وللملوثات:- (pH ,Oil , T.S.S , BOD_5 ,COD ,N-NH_3 ,Sulfide ,Sulfate , Phosphorous and Phenol)
النتائج اظهرت الاداء الكفوء لمحطة المعالجة في ازالة الملوثات (T.S.S ,OIL ,BOD , COD ,Sulfide , Phenol) حيث سجلت اعلى نسبة ازالة لهذه الملوثات وهي 95% , 88% , 86% , 81% , 85% و97% على التوالي وكذلك النتائج اظهرت ان محطة المعالجة ليست كفوءة جدا في ازالة الملوثات NH_3 , SO_4 and PO_4 .

KEYWORDS
Oil Refinery effluents, wastewater treatment plant, evaluation of the performance.

INTRODUCTION

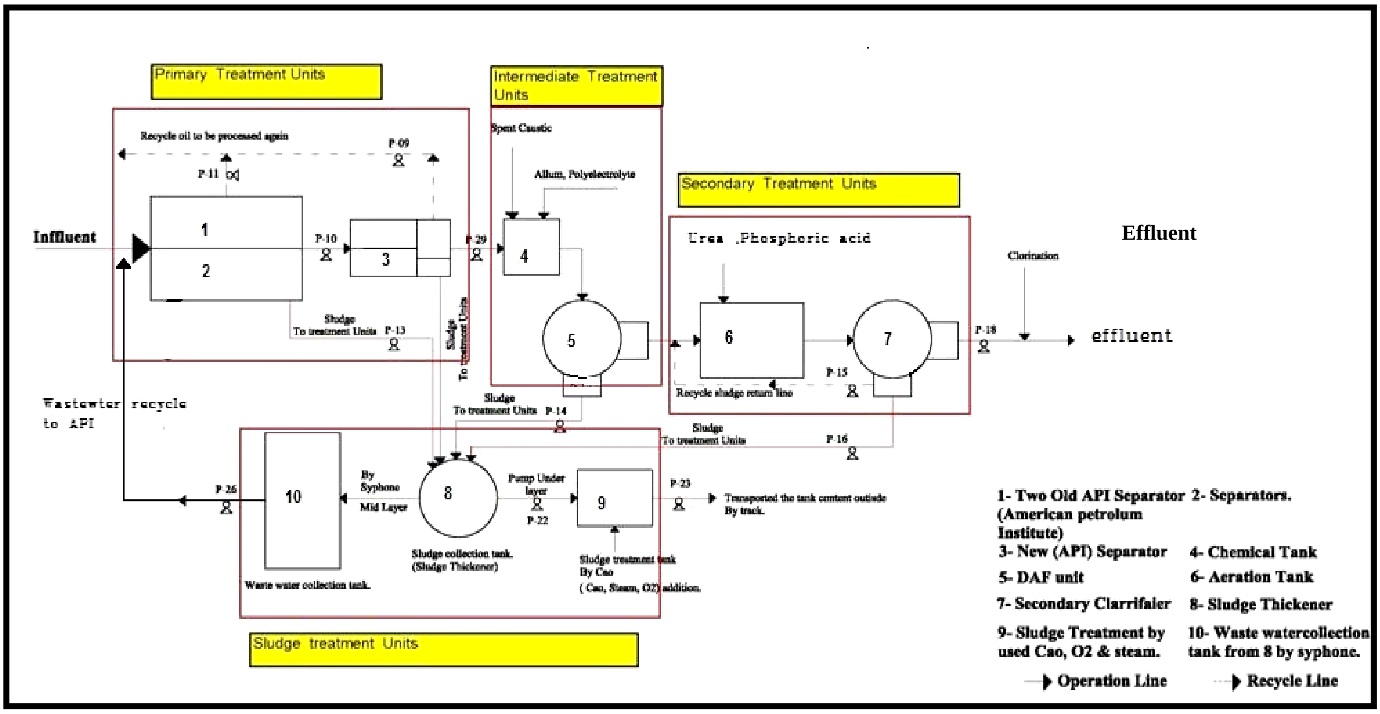
Pollution generally may be defined briefly as the total disturbance of natural surroundings. Water pollution may be defined as the existence of some , Chemical , Physical and Biological elements that exceeds the allowable standard limits. The presence in significant quantity of any extraneous material (solid , liquid , gas) in any particular location may therefore constitute pollution .

0ne of the industrial sources of pollutants is the refinery effluents, being significant water consumers and consequently large wastewater producers . In this research the performance of the wastewater treatment plant of the Dora Refinery will be studied . This study will be conducted in order to specify the problems and hence , to suggest the solution and recommendations for better performance .

GENERAL DESCRIPTION OF THE DORA REFINERY WASTEWATER TREATMENT PLANT

The Dora refinery was operated in 1955, and is located at the southern region of Baghdad city on the right bank of the Tigris river. The average Refinery Wastewater is approximately 750 cubic meter per hour ; at normal conditions ; reaching to 850 cubic meters per hour in rainy seasons . The wastewater is discharged to the Tigris River after treatment .The Dora Refinery Wastewater contains several pollutants including variable concentrations of oil, phenols, suspended solids, sulfides, oxygen demand, bearing material and other harmful contaminants. A treatment plant was constructed and operated in 1980 . In spite of this it was noticed that sometimes the quality of the refinery discharged effluents had exceeded the Iraqi discharged water quality limitations, leading to harmful environmental impact on the Tigris River.The location of Dora refinery along the Tigris river in Baghdad is just upstream of the industrial complex.The present Dora refinery wastewater treatment plant started operation in 1980 and the two old "API " separators constructed earlier in 1955 were connected with the new treatment facilities. Fig.(1) shows the treatment plant units.

Fig.(1):The Dora refinery wastewater treatment plant units .



EXPERIMENTAL WORK

Parameters Needed

Before testing the quality of petroleum refinery effluents , potential parameters should be identified for successful interpretation of the experimental results obtained .The quality of refinery effluents can generally be assessed by monitoring the most popular parameters such as Oil , BOD_5 , COD , Sulfide & Sulfate , Nitrogen compounds (NH_3 ,NO_3) , Phosphorous , Suspended Solids and Phenols .[1&2] .

Sampling Technique

In this study , a series of (12 Grab Samples) were taken from 6 selected locations in the plant in order to detect the influent and effluent quality fluctuations . The total of (72 Sample) were taken during the sampling period of {14 May to 17 Oct. 2006 } . At an average of two samples per month.

Sampling Locations

In each time of the (12 Grab sampling) , samples were taken before and after each stage at the Dora refinery wastewater treatment plant . This was done in order to obtain a clear picture of the performance of each stage alone .

Experiments And Equipments Used

Experiments used for testing the Dora Refinery wastewater contaminants were chosen depending on the expected concentrations of the effluents and on the recommended tests applied by the{Standard Methods for the examination of water & wastewater } hand

No.	Parameter	Experiment	Reference
1-	Oil & Grease	Partition – Gravimetric method	" The standard method for examination of water and wastewater " page(5-25)(18)edition
2-	Total suspended Solids	Filtration on filter paper	The same above page (2-56)
3-	pH	Direct Measurement	= = = = page (460)15^{th}.edition
4-	BOD_5	Direct Measurement	New digital bottles
5-	COD	2 hour– Dichromate	" The standard method for examination

book,[1985 ,1988 & 1990]
These experiments were carried out in the Dora wastewater treatment plant laboratory . The parameters tested , experiments and equipments used are stated in table (1) .

Table (1) Experiments and equipments used.

		method	of water and wastewater " page (5-7)(18)edition
6-	Ammonia (NH_3)	Nesslerization Method	= = = = page (4-78)(18)edition
7-	Nitrate (NO_3)	Not measured (unavailable reagent)	= = = = page (*)
8-	Sulfide	Spectrophotometer	New digital device
9-	Sulfate	Spectrophotometer	New digital device
10-	Phenols	Chloroform extraction method	" The standard method for examination of water and wastewater " page (5-31)(18)edition
11-	Phosphorous	Spectrophotometer	New digital device

Experimental Results

The experimental results of the Dora refinery wastewater are listed in (10) tables . These results represent the wastewater characteristics at 6 different stages & during the sampling period of [14 May to 17 October, 2006].

Note :During the sampling period the refinery was exposure to electrical shut down, that may affect the results.

ANALYSIS OF RESULTS AND DISCUSSION

Representation of Results

The experimental results that mentioned above were analyzed to obtain the following results in others 10 tables , each table is separated as the following :-

1-Table (A) involve the concentrations for each pollutants in the six treatment stages.

2-Table (B) involve the (standard deviation ,minimum ,maximum ,average & design limitation) for each pollutant in the six treatment stages.

3-Table (C) involve the pollutant removal percentage in each treatment stage ,their average and standard deviation .

The pollutants concentration in tables (B) were plotted against the designed limits of the Dora Refinery Wastewater Treatment Plant to show the difference between the design and the actual performance conditions in figures (2 to 11).The Dora Refinery discharged effluents are also studied and plotted with the Iraqi discharged water quality limitations in figures (12 to 22).Table (2) for T.S.S pollutant represent the typical table of these 10 tables that mentioned above, and the analysis of the others pollutant showed graphically.

Analysis and Discussion

The actual performance of the Dora Refinery Wastewater Treatment Plant will be analyzed and discussed according to the experimental results of the pollutants concentrations , which were considered as the criteria of performance , as follows :

Wastewater Flow Rate

Figure (12) of the wastewater flow rates show normal conditions within the design limit of (750 to 850 m^3/hr) in the (first, second, sixth, tenth, eleven and twelve) sample values are (800 m^3/hr) during this sampling period . The others six samples the values are (750 m^3/hr)..

pH Values

Figure (2) show the range of the wastewater pH at different treatment stages of the wastewater treatment plant. It can be seen that the pH values of the second stage effluent of the chemical tank and DAF unit increase slightly due to the addition of chemicals for pH adjustment in this stage .The results indicate the suitable control of pH. Fig.(13) shows the pH values of the Dora refinery final effluents discharged to the Tigris River . these discharged values are all within the range of the Iraqi water quality limitations .

Total Suspended Solids

The total suspended solids concentrations , at different treatment stages , are illustrated in table (2)(A) .These existing concentrations were plotted against the designed concentrations in fig. (3).The maximum and the minimum concentrations values seemed to be close to the design performance of the treatment plant .The total suspended solids concentration decreased with the operation of the DAF unit ,but in July and August the samples from DAF unit showed a slight increase in the T.S.S concentration. This may be related to the formulation of flocs in the chemical addition tank .because of these flocs are from the spent caustic stream(that does not enter the plant in the influent pit) did not settle properly. Also the low removal percentages in this unit is due to the low air pressure used for design Rohlich .[58]
The removal reached to 3.9% for sample 1 , 15.4% for sample 9 and 8.6% for sample 11.
The T.S.S measurements from the biological treatment unit (6) were very high indicating the high micro-mass production in this tank. The removal efficiency was not recorded as this unit is not for solid settlement.The final T.S.S concentrations in the effluent were within the Iraqi discharge limitations as shown in fig.(14) and the overall removal of the plant was at an average of 95.2% .

Oil and Grease

Figure (4) also shows that the oil concentrations (max. ,min. & average) were very close to the designed performance of the treatment plant .that can be related to the API gravity separators especially the new one.The effect of the new API separator operation is clearly observed for oil removal, but it decreased to 39.1% in May and 17.8% in August .

Ingersoll ,(1951). indicated that the API performance might be disturbed by excessive concentrations of suspended solids present in the API basin , due to the presence of some suspended matter that neither floats nor settles down , thus creating a poor gravity reduction in oil and suspended solids concentrations .The DAF unit default also in oil removal in May as the removal reached 2.6% and in July 8.2% .Gehr and Henry (1978). reported that the DAF recycled liquid should always be the clearest liquid obtainable from DAF unit, in order to gain the polymer build-up in the DAF unit for better flotation process, but the refinery uses tap water . The poor performance of the DAF unit also may be related to the low saturation pressure used in pressurization tank . The oil concentrations of the final effluents are illustrated in figure (15) . This graph shows the fluctuations in oil concentrations during the sampling period , indicating that the maximum concentration was (9.6 mg/l) of the first sample tested. Where the removal was 54.3% .The overall of the plant was between 69% - 100% . All the samples were under the Iraqi limitations of 10 mg/l .

Biochemical Oxygen Demand (BOD)

It can be seen from figure (5) that the effluent (BOD_5) values of the aeration tank were high in all samples tested . This is normally related to the suspended organic load of the biological floc which is recirculated from the final settling tank back to the aeration tank . However , these high suspended (BOD_5) values are reduced again in the final settling tank , which were less than the design limit of 20 mg/l . In figure (16) the discharged values of (BOD_5) were plotted with the Iraqi limitation of (40 mg/l).The results indicate the low (BOD_5) concentrations discharged to the Tigris River . The overall removal of the plant ranged from 68% to 90.6% .

Chemical Oxygen Demand (COD)

Figure (6) showed the COD results are within the design limitation . Excluding the API and DAF units in June where the minimum concentration were over the minimum design limits which lead to low COD removal of 9.8% and 4.4% .The COD concentrations in the final effluent ranged between 8 mg/l to 68 mg/l , that were below the Iraqi limitations of 120 mg/l .The plant had an average COD removal of 86.2%. .

Nitrogen and Phosphorous

The results of the conducted tests are plotted in figures (7 and 10) at different treatment stages , to show their fluctuations throughout the stages of treatment no design values for the internal stages were found , but only for influent and effluent from the whole treatment plant.The results indicate the degradation of NH_3 and PO_4 concentrations through the API and DAF units . But the increase in NH_3 and PO_4 concentration in the aeration tank were related to the high amounts of Urea and Phosphoric acid added in this tank as a source of nutrients . Generally , these amounts are governed by the rule of :-
100%BOD_5 : 5% Nitrogen : 1% Phosphorous . by Bush , (1980) . However , the proportions of these nutrients added in the Dora refinery wastewater aeration tank were 100% BOD_5 : 10% Nitrogen : 1% Phosphorous. The concentrations decreased in the effluent from the final settling tank with respect to the aeration tank . The concentrations of NH_3 in most of the samples were high compared with the design limitations of 0.3 mg/l . According to Concawe limitations of 0.5 mg/l for final disposal , samples 8 and 9 showed high NH_3 concentration of 1.62 mg/l and 1.7 mg/l respectively . For PO_4 concentrations all samples of the final effluent were low compared with the Iraqi limitations. The overall removal for NH_3 was 58.4% and 20.9% for PO_4 .

Sulfide & Sulfate

Figures (8 & 9) showed The concentration of sulfide decreased through the treatment processes , but it was difficult to evaluate the efficiency of each unit due no design

limitations. The final effluent was low in sulfide concentrations (less than 0.3 mg/l) for all of the tested samples . A high removal efficiency was observed that reached 99.2% in May . The average removal was calculated to be 85.2% . Also no design limitations were provided for sulfate removal in the treatment units . According to the Iraqi limitations for disposal , the sulfate concentration in the effluent should be (+ 1%) of the inlet . This is due to the sulfate production from the degradation of the organic matter in the treatment units . Another increase in sulfate concentration is from the oxidation of thiosulfate in the chemical addition tank .Figure (19) show the concentrations of the discharged (Sulfides) to the Tigris River , during the sampling period .The results were plotted against the English standards discharged concentrations of (Sulfide) , since no Iraqi (Sulfide) limitations exist .
Figure (20) show the (Sulfate) effluent concentrations discharged to the Tigris river . The concentrations range between 122 mg/l to 400 mg/l .

Phenols

The results indicated that the concentrations of phenol in the wastewater treatment plant for most samples tested were higher than the designed limits of Dora refinery wastewater treatment plant.The effluents from API and DAF contain phenol concentrations more than the design limitations of 0.74 mg/l and 0.72 mg/l respectively as shown in fig.(11).This may related to the in – plant treatment that was not practiced in a proper way, for separating phenol from the waste of the units which deal with phenols such as (light petroleum oil units).The decrease in phenol was observed in the aeration tank for all the samples tested and was less than 0.1 mg/l . The final effluent discharged to the river was low in phenol only for one sample tested in June which contained 0.06 mg/l compared with the Iraqi limitation 0.05 mg/l .Figure (22) show the concentrations of discharged phenols to the Tigris river .The treatment plant was efficient in phenol removal that reached to an average of 97.7% .

Table (2)-(A): ITEM NAME :-(T.S.S.)Measurements													Table(2)-(B):- Measurements Analyses					
Sample set no.	1	2	3	4	5	6	7	8	9	10	11	12						
date of experiments	14-5	28-5	05-6	25-6	02-7	23-7	13-8	28-8	05-9	27-9	9-10	17-10	ST. DEV.	Aver. Actual	Min. Actual	Max. Actual	Min. Design	Max. Design
Sample Location																		
A-Inlet	171	175	182	198	239	237	225	185	216	198	215	188	23.54	202.42	171	239		
B-API-eff-P10	14.7	20.4	22.6	32.6	34.5	34.6	20	19	21.2	16.6	28.6	23.8	6.89	24.05	14.7	34.6	500	1000
C-new API-eff-P29	12.8	18.2	15.7	21.7	22.3	27.4	11.8	11.8	15.6	8.2	15.2	N.P	5.59	16.43	8.2	27.4	50	100
D-DAF-S09	12.3	7.8	8.2	10.3	11.5	13.1	21.2	21.4	13.2	13.6	13.9	N.P	4.45	13.32	7.8	21.4	20	30
E-Bio. Treat.-S10	1482	1520	1430	3000	3700	2000	3100	3270	3340	3220	2550	2640	806.23	2604.33	1430	3700	2800	4000
F-final dis.-P18	15.8	7.8	8.3	5.5	7.8	10	9.2	7.4	9.06	9.4	14.4	9.4	2.89	9.51	5.5	15.8		10

Table (2)-(C):- (T.S.S) units percentage removal

Sample date	14-5	28-5	5-6	25-5	2-7	23-7	13-8	28-8	5-9	27-9	9-10	17-10	ST.DEV.	Average
R1%	91.4%	88.3%	87.6%	83.5%	85.6%	85.4%	91.1%	89.7%	90.2%	91.6%	86.7%	87.3%	0.03	88.2%
R2%	12.9%	10.8%	30.5%	33.4%	35.4%	20.8%	41.0%	37.9%	26.4%	50.6%	46.9%	N.P	0.23	37.2%
R3%	3.9%	57.1%	47.8%	52.5%	48.4%	52.2%	*******	*******	15.4%	*******	8.6%	N.P	*******	*******
R4%	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
R5%	98.9%	99.5%	99.4%	99.8%	99.8%	99.5%	99.7%	99.8%	99.7%	99.7%	99.4%	99.6%	0.00	99.6%
Ro%	90.8%	95.5%	95.4%	97.2%	96.7%	95.8%	95.9%	96.0%	95.8%	95.3%	93.3%	95%	0.02	95.2%

Where:-R1=eff. Of old API , R2=eff. Of new API , R3=eff. Of DAF unit , R4=eff. Of aeration tank , R5=eff. Of final clarifier, Ro=eff. Of overall treatment plant

********= Negative value**

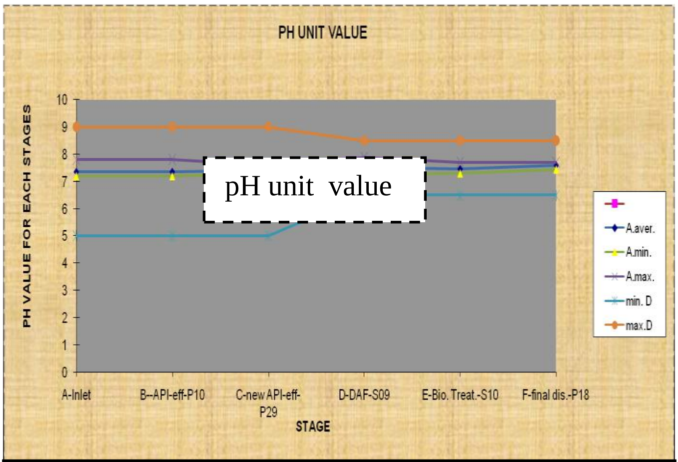


Figure (2): Existing practical and the Designed of (pH) value through stages of the Dora Refinery Wastewater Treatment Plant.

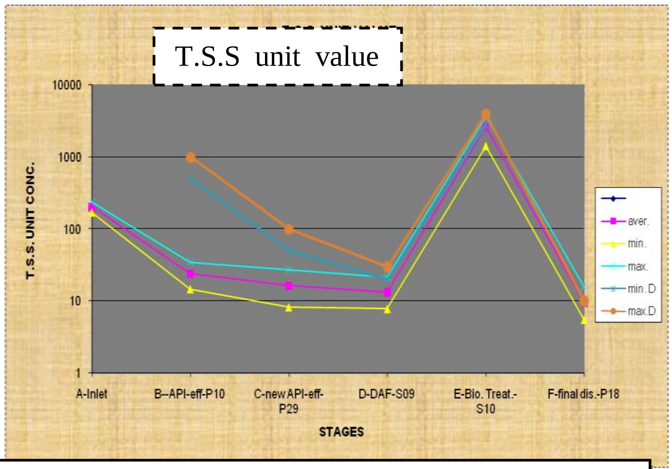


Figure (3): Existing practical and the Designed of (T.S.S.) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

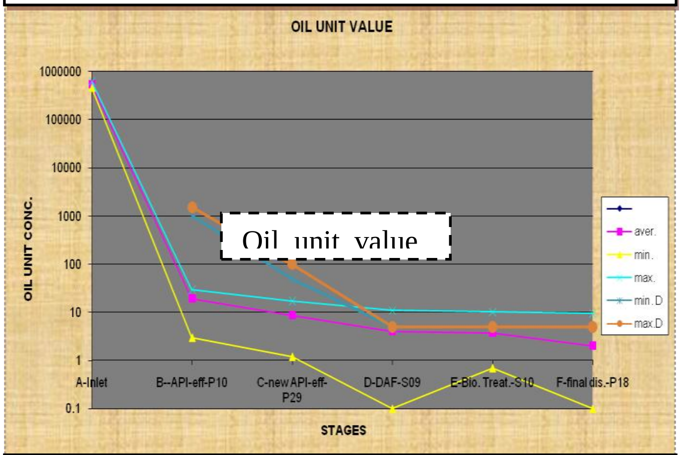


Figure (4): Existing practical and the Designed of (Oil) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

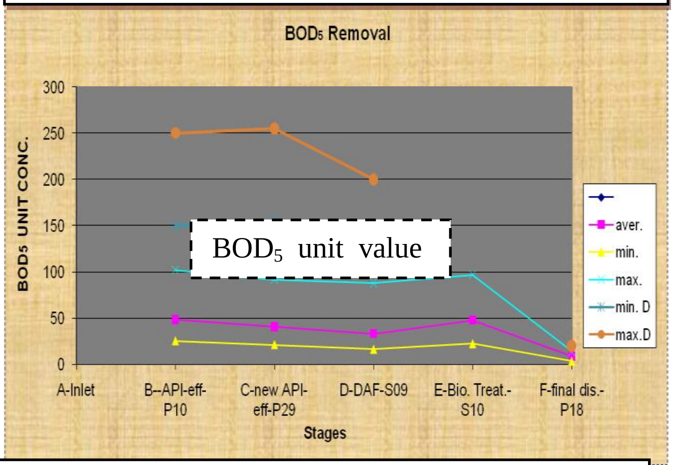


Figure (5): Existing practical and the Designed of (BOD_5) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

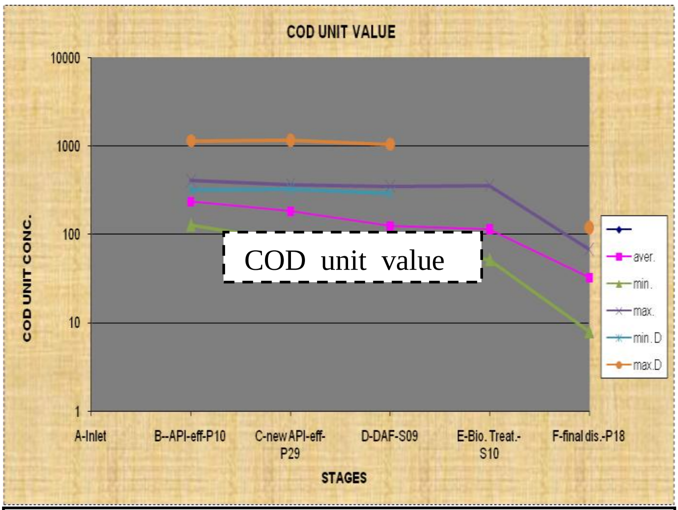


Figure (6): Existing practical and the Designed of (COD) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

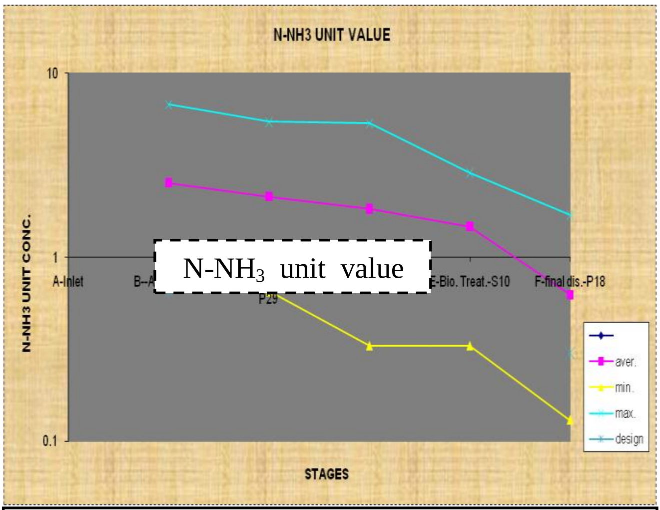


Figure (7): Existing practical and the Designed of ($N-NH_3$) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

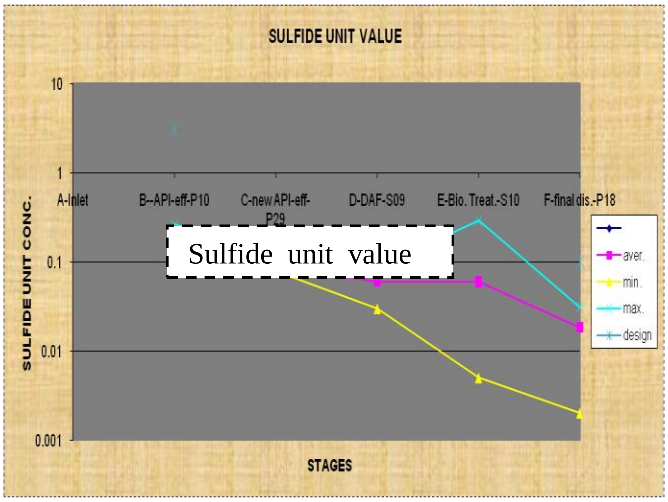


Figure (8): Existing practical and the Designed of (Sulfide) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

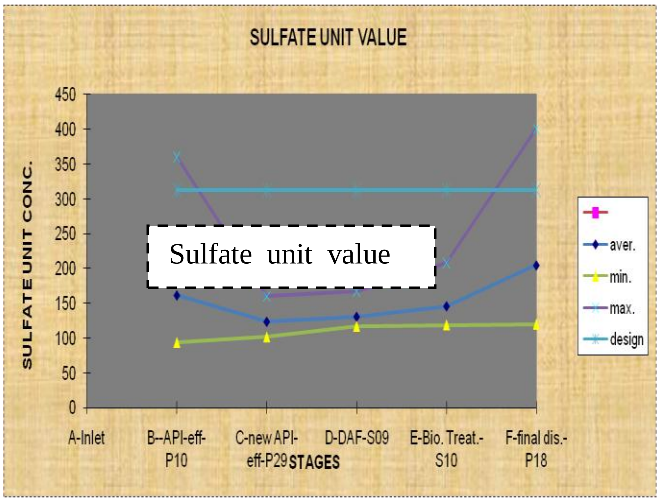


Figure (9): Existing practical and the Designed of (Sulfate) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

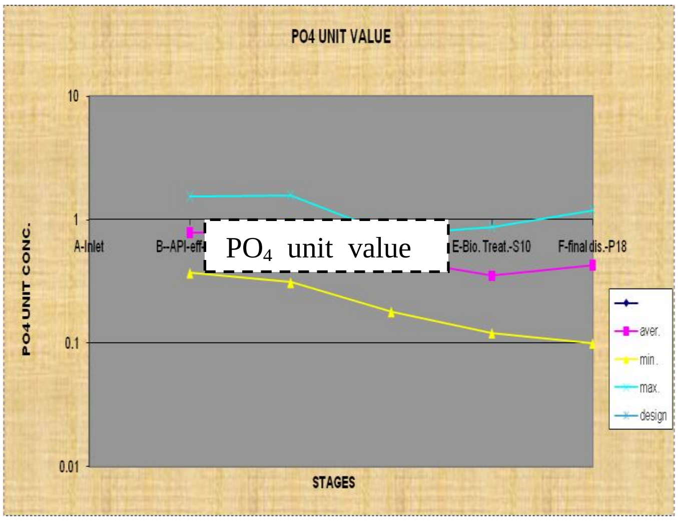


Figure (10): Existing practical and the Designed of (phosphorus) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.

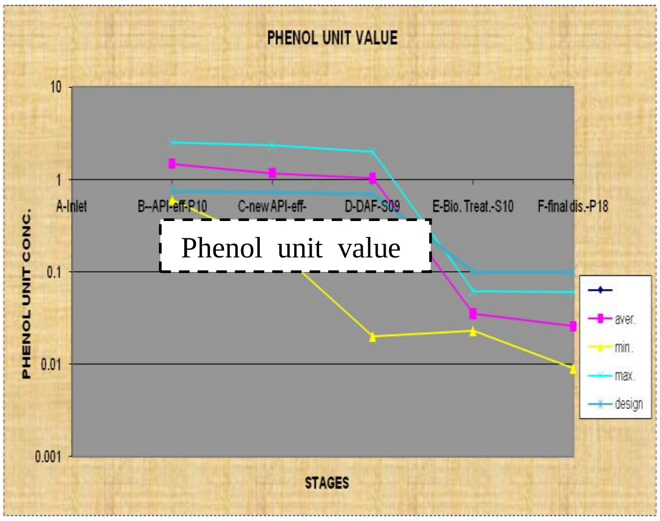
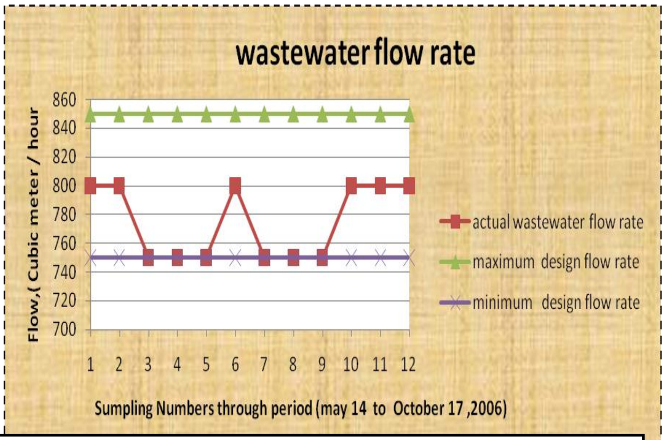


Figure (11): Existing practical and the Designed of (Phenol) Concentrations through stages of Dora Refinery Wastewater Treatment Plant.



Figure(12): Existing and the designed (Flow) of the wastewater in the Dora Refinery Wastewater Treatment Plant during the sampling period .

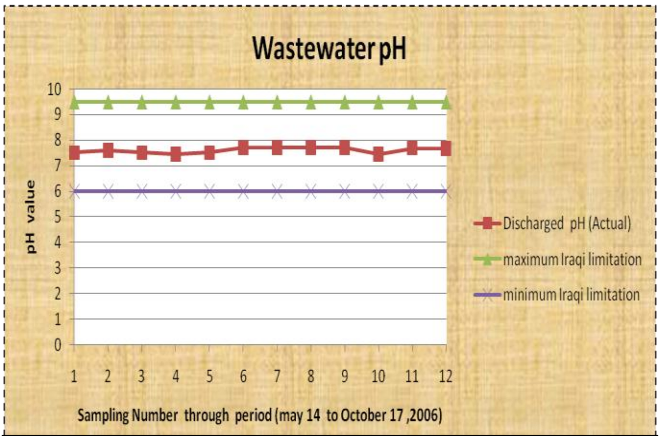


Figure (13): (pH) Discharged values of the Dora refinery wastewater treatment plant during the sampling period compared with the Iraqi Limitations .

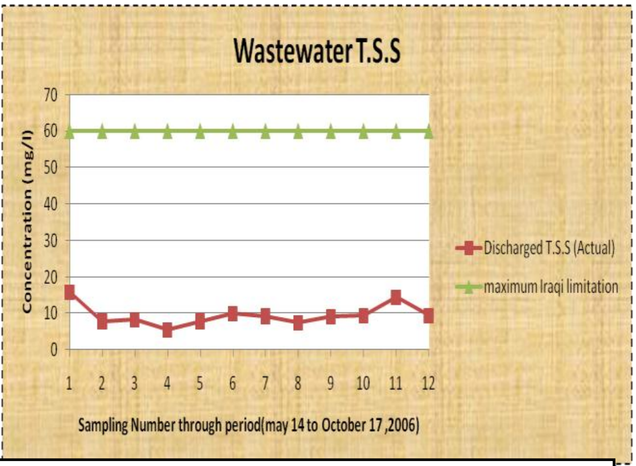


Figure (14) : (T.S.S.) Discharged Concentrations of The Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitation .

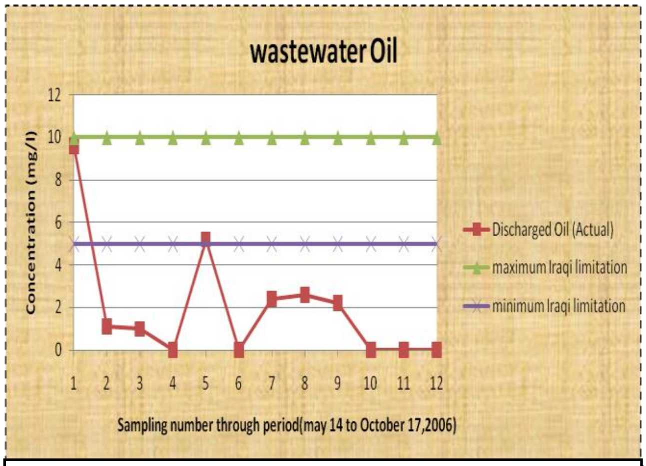


Figure (15) : (Oil) Discharged Concentrations of the Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitations .

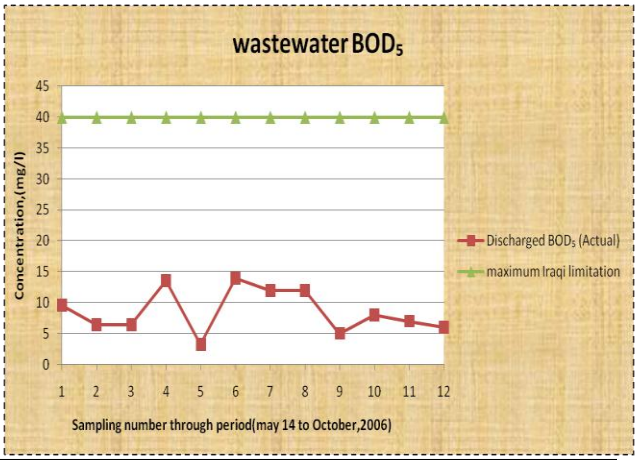
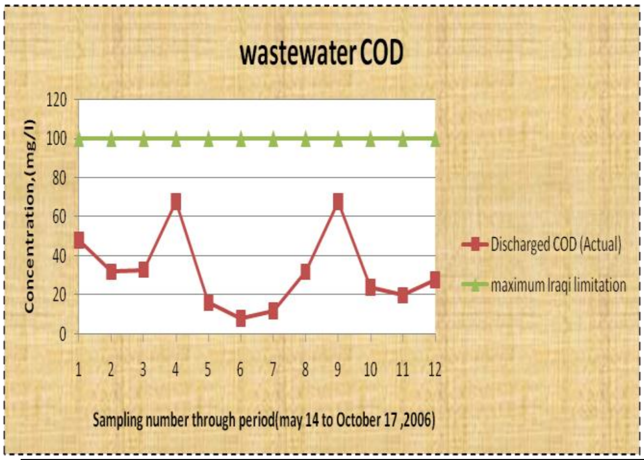


Figure (16) : (BOD_5) Discharged Concentrations of the Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitations .



Figure(17) : (COD) Discharged Concentrations of the Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitations .

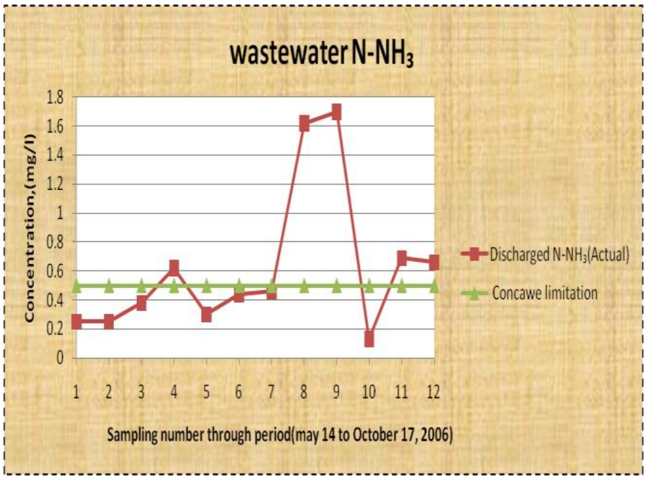


Fig.(18) : (($N\text{-}NH_3$) Discharged concentrations of the Dora refinery wastewater treatment plant during the sampling period compared with (Concawe) discharge water limitations .

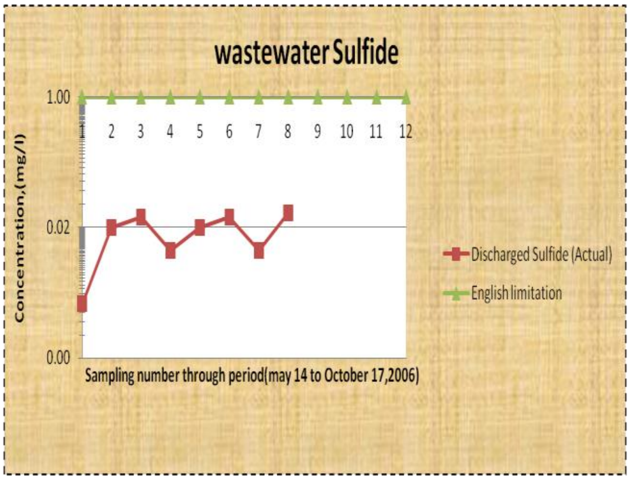
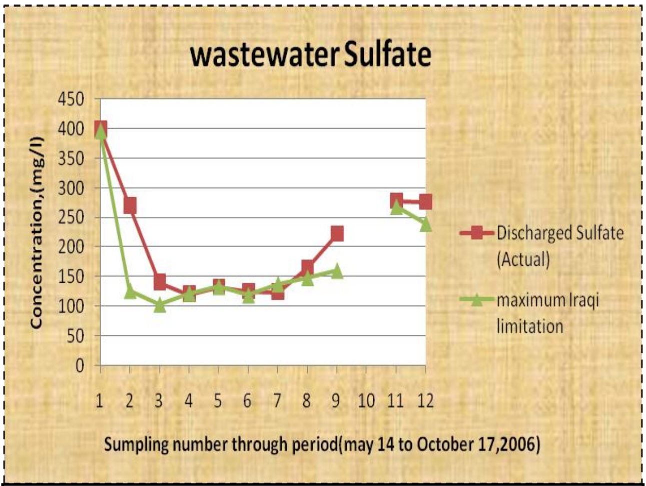


Fig.(19) : (Sulfide) Discharged concentrations of the Dora refinery wastewater treatment plant during the sampling period compared with (English) discharge water Limitations



Figure(20) : (Sulfate) Discharged Concentrations of the Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitations .

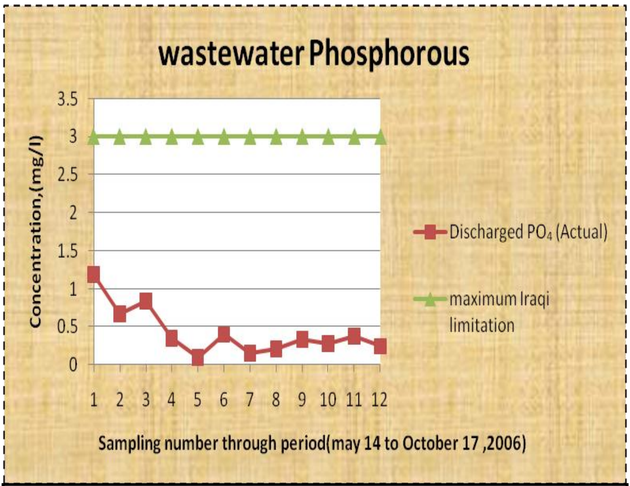


Fig.(21) : (PO_4) Discharged Concentrations of the Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitations .

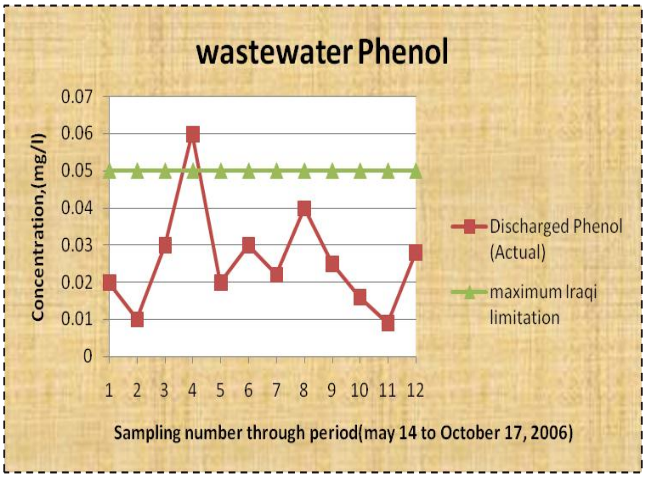


Figure (22) : (Phenol) Discharged Concentrations of the Dora Refinery Wastewater Treatment Plant during the sampling period compared with Iraqi discharge water Limitations .

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

From the study of the conditions of the Dora refinery wastewater treatment plant and its final effluent discharged to the Tigris River , the following conclusions could be drawn :-

1- The influent of the treatment plant is of high diversity , in both quality and quantity , due to the fact of having a single collection system of wastewater from :different processing units of the refinery, rain water runoff , and domestic sewage wide fluctuations in the performance of the Dora refinery wastewater treatment plant were detected and can be related operational problems .

2- The performance or the API separators effects the malfunctioning in the downstream units . The API was high in oil and suspended solid removal which was reflected on the final effluent.
3- The (DAF) unit faced operational problems.Caused by, first the low air pressure to form the desired air bubble size . Second not recycling it's effluent for the formulation of the required polymer for emulsion.
4- The performance of aeration tank in regard to the removal of dissolved organics and chemical compounds was good . This is due to the good aeration process .
5- The large amounts of Urea and phosphoric acid being added to the aeration tank is believed to be the reason of the relatively high concentrations of dissolved ammonia (NH_3) and PO_4 discharged to the Tigris River.
6- The reuse or recycling some of the refinery effluents are not practiced in the Dora refinery wastewater treatment plant .
7- The treatment of sludge was practiced by adding chemical material (CaO)with steam and continuous agitation in order to change the sludge From a hazard waste to an environment friendly material.
8- In general high removal efficiencies were obtained for T.S.S , oil , COD ,BOD , Sulfide and phenol , which were 95% , 88% , 86% , 81% , 85% And 97% respectively. And the plant was not very efficient in NH_3,SO_4 and PO_4 removal.
9-The annual percentage removal of sulfide , oil ,COD ,BOD and T.S.S.,were found acceptable except for the T.S.S. value which shows relatively low removal percent 67.58% .
10-The monthly percentage removal of sulfide , oil , COD , BOD and T.S.S. shows considerable changes among different months of the years ,which may reflect considerable variation in influent water properties and treatment process.

Recommendations

1- The in- plant treatments are believed to be essential, i.e , treatment after each production unit before sending the wastewater to the sewer system .These treatments include (source reduction , reuse , recycling & recovery) .

2-Dilution of the strong influent with the less contaminated waste streams before treatment is highly recommended. This is to ensure the equalization and the utmost efficiency of the plant.
3- The separation of the different wastes reaching the inlet pit . Domestic sewage and storm water should be disposed to the main city sewer system either as in a combined or separate systems . The wastes from the processing units in the refinery should only reach the treatment plant for proper treatment.
4- The performance of the DAF unit can be improved by :-
A- using high pressure this will help for better saturation of air in water .
B- recycling of the effluent for better polymer formation .

5- Installation of interface Oil / water level indicators in the three Oil separators where Oil layer at the surface is thick, in order to improve the separation of oil and grease from the water - grease mixture and reduce the pollution of wastewater with petroleum waste.
6- Adding the proper quantities of Urea to the aeration tank will decrease the levels of the dissolved ammonia (NH_3) in the final effluents discharged to the Tigris river.
7- Installation of flow meters in the wastewater treatment plant is essential to control the addition of chemicals at different flow rates.

8- Environmental awareness and up to date operational courses are recommended to be conducted for staff members. These courses will outline the environmental impact of refinery effluents and the refineries commitment to water quality improvements.

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