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Performance Assessment of Al Muamirah Wastewater Treatment Plant "Using Statistical Analysis" at Hilla city, Iraq

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Abstract

The evaluation was based on the plant operation data such as BOD_5, COD, TSS, T.N, PO_4, NH_3, SO_4, NO_3, Cl, and Oil&Grease for the period of 11months from Oct. (2020) to Aug. (2021). Data taken from a laboratory in the wastewater treatment plant and compiled in Excel software. The results showed that the efficiency of removal of BoD_5, COD, TSS, T.N, PO_4, NH_3, SO_4, NO_3, CL, and O&G was 92.68%,78.97%,94.27%,62.61%,81.83%,83.32%, 8.71%,61.53%,12.29%, and 88.88% respectively on a monthly basis. Accordinig, it can be recommended that the Al-Muamirah wastewater treatment plant has an acceptable efficiency except for the efficiency of sulfates and chlorides that are not acceptable please treat them in the future. A multivariate statistical technique of the data has been attempted by applying cluster analysis using a statistical (SPSS). Cluster analysis shows that months (December20, February21, October20, January21 and November20) indicate a good level of treatment compared to that of (March21, May21, August21, Jun21, July21 and April21).

Key words: Efficiency, Cluster Analysis, Months, Al Muamirah Wastewater Treatment Plant.

1. Introduction

Wastewater treatment plant play a significant role in protecting the environment. Thus, it is essential to keep them operating effectively so that the concentrations of contaminants they release into rivers after being treated within acceptable limits [1].

Because people are becoming more worried about the environment, they are paying more attention to how STPs are run and controlled. Since the waste from STPs is discharged into a

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body of water, if they are not run correctly, they could cause serious environmental problems. Sewage treatment plants are built and run to work like natural treatment systems. In this case, it's essential to pay extra attention to figure out how existing sewage treatment plants affect the environment [2].

A performance evaluation of the existing treatment plant is needed for two reasons:

(1) To determine the quality of the existing effluent or meet higher standards for treatment; also

(2) To find out about the treatment plant and if it can handle higher water and organic loads.

Wastewater is the community's water supply after many different uses have polluted it. During its use, the water in a community picks up various chemicals. This means that the wastewater has the potential to pollute and becomes a health and environmental hazard [3].

The present study aimed to statistical analysis of quality parameters of Muamirah Sewage Treatment plant at Hilla city.

A complete outline of the plant units is shown in Figure (1) and specifications of Al-Muamirah project treatment units are shown in Table (1).

Figure (1): Image map of Al Muamirah sewage treatment plant, Hilla [Al-Muamirah project office, 2021]

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Table 1. Al- Muamirah project treatment units

No.	Location Name	
1	Coarse screen	It is the first step in the preliminary treatment stage and consists of three units that remove large items from the flow stream
2	Fine screen	It has three parts that are used to remove fine solids and protect equipment that might be more sensitive to solids
3	Anaerobiotic tanks	These tanks have an anaerobic treatment stage. In the first stage, anaerobic bacteria take out nitrates and some of the phosphorus
4	Oxidation basins	There are two big basins. Each basin is about 6 meters deep. Each basin has five oxygen-adding motors and ten submersible mixers that reduce sedimentation, add oxygen and help aerobic bacteria grow
5	Distribution basin	It has three arcs that move water to the sedimentation tanks, drain treated water to the contact tank, and move sludge to the return tank.
6	Sedimentation basins	It is separate the treated water from the sludge. Also, solids that float to the top are thrown away, and clean water is sent to contact tanks.
7	Alum room	Is added to water before it reaches to contact basin
8	contact basin	The last stage in which treated water goes to drainage or for irrigation
9	Chlorine room	In the contact basins, the sterilization process takes place. Microorganisms and microbes are killed by adding chlorine to the water in these basins.
10	Drying basins	These 16 drying tanks use filters to separate sludge and let it dry in the sun

2. Materials and Methods

2.1 Data collection

The evaluation of the plant's performance efficiency was carried out about the effluent quality. The assessment was conducted using operational data from the plant, Certain data have

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been collected monthly from influent and effluent in Al Muamirah Sewage Treatment Plant which included BOD_5, COD, TSS, T.N, PO_4, NH_3, SO_4, NO_3, Cl, O&G, pH, and T measurements for the period of 11 months from Oct (2020) to Aug (2021) as shown in Table (2) & (3).

Table (2) Influent Data for Wastewater Treatment Plant

Influent												
Month	BOD5raw	CODraw	TSSraw	T.Nraw	PO4raw	SO4raw	NH3raw	Clraw	O&Graw	pH raw	NO3raw	Traw
October-20	147	243.67	184	16.68	3.87	882	10.73	414.5	14.95	7.466	5.583	24.75
November-20	116.6	179.5	240.5	295.966	6.2	803	14.92	411.8	12.7	7.65	6.66	22.66
December-20	181	328	344	17.04	7.47	1039	18.5	434.75	15.35	7.48	6.15	21.5
January-21	127.5	226	139.5	15.87	10.75	944	17.6	379	23.75	7.31	4.225	19.4
February-21	371.5	567.5	454	24.15	19.9	992	22.45	434	14.75	7.28	3.7	20.9
March-21	96.5	141.75	110	10.25	4.025	792	13.7	606.5	12.2	7.2	1.66	23.35
April-21	116.6	162	160.33	15.1	5.09	819	14.35	515.66	14.1	7.74	1.4	26.25
May-21	165	231.5	196	12	5.7	861	19.2	520.5	13.7	7.66	1.8	28.5
June-21	168.5	215.83	171.83	11.25	3.125	864	10.75	525.25	16.15	7.4	1.1	29.51
July-21	167	198	162.5	16.55	12.5	863	18.9	480	17.2	7.35	0.9	31.5
August-21	110	173.5	129.5	8.96	5.15	913	12.6	568.5	17.3	7.34	1.2	29.35

Table (3) Effluent Data for Wastewater Treatment Plant

Effluent												
Month	BOD5final	CODfinal	TSSfinal	T.Nfinal	PO4final	SO4final	NH3final	Clfinal	O&Gfinal	pHfinal	NO3final	Tfinal
October-20	13.3	47.67	10.67	8.98	1.26	855.5	2.26	355.5	1.5	7.49	2.23	24
November-20	11.67	32	14.17	8.86	1.32	762	4.375	359.66	2.85	7.43	1	21.83
December-20	10.4	45	9.8	6	1.38	900.5	1.6	372.75	1.7	7.594	2.45	79
January-21	10.5	40	17.75	8.1	1.26	875	3.3	331.66	1.85	7.22	1.05	19.27
February-21	9	52	10.5	7.8	1.2	889	3.45	324	2.1	7.475	2	20.6
March-21	8	63	8.25	3.4	0.875	754	2.05	525.25	1.66	7.29	1.53	23.25
April-21	6	58	9	2.26	0.803	761	1.75	520	1.4	7.71	1	27.5
May-21	27.5	45.5	11	4.45	1.35	789	3.1	453	1.2	7.485	2.15	28.5
June-21	8.67	57.5	8.83	1.125	1.1	719	1.4	464.5	1.7	7.26	0.53	30.166
July-21	12	36.5	13.5	1.25	1.4	719	1.1	515	1.1	7.695	0.7	30.95
August-21	9.75	56.5	14.75	2.8	1.56	822	0.4	472.5	2.4	7.32	1.6	32.35

Removal Efficiency

Utilizing the following formula, the removal efficiency of BOD_5, COD, TSS, T.N, PO_4, NH_3, SO_4, NO_3, Cl, and O&G was determined.

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$$\text{Removal efficiency \%} \quad (P) = {}^{Pinf - Peff}/_{Pinf} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

Were

P is the selected parameter

P_{inf} is the mean influent, and

P_{eff} is the mean effluent.

3. Results and Discussion

3.1 Statistical Analyses

To describe the quality of the wastewater, mean, standard deviations, minimum and maximum values, and selected parameters were calculated from the data. Table (4) shows descriptive statistics for the plant's water quality data.

Table 4. Statistics about the quality of the water at the Muamirah WWTP (2020-2021)

Parameter	Influent					Effluent				
	Min	Max	Mean	St.Dv	No	Min	Max	Mean	St.Dv	No
BOD_5	75	573	149.79	92.42	44	4	49	10.95	6.75	44
COD	98	893	229.97	158.16	44	10	89	48.36	21.23	44
TSS	77	901	202.73	165.07	44	3	44	11.61	7.51	44
T.N	2	30	14.71	5.74	44	0.1	14	5.5	4.09	44
PO_4	1.7	33.6	6.77	5.81	44	0.01	1.95	1.23	0.5	44
NH_3	0.7	28.2	14.87	5.34	44	0.4	5.1	2.48	1.43	44
SO_4	792	1106	899.46	87.33	44	719	910	821.07	62.66	44
NO_3	0.6	10.1	3.64	2.82	44	0.0002	6.4	1.40	1.33	44
Cl	354	715	483.22	87.1	44	301	560	423.8	79.54	44
O&G	6.3	28.2	15.57	7.88	44	0.1	3.1	1.73	0.8	44
pH	6.6	7.96	7.44	0.25	44	6.64	8.14	7.42	0.29	44
T	18.4	32	24.92	3.86	44	18	822	45.1	127.76	44

The composition of waste-water effluent differs between facilities depending on the level of treatment. This could be one of the main reasons why pH levels change so much [4].The pH affects the suitability of a water system for various applications. It is well recognized that pH levels which are either extremely high or low can be harmful to aquatic life and can change the

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solubility of both other chemical pollutants and certain essential components found in water systems, which can have severe effects on the environment [5].

During the study period, the pH value of the influent (6.6-7.96) and pH value of the effluent (6.64 - 8.14) were generally alkaline, with mean values of 7.44 and 7.42, respectively as shown in (Table 4). The increase in effluent pH is caused by a decrease in dissolved CO2 concentration as a result of the oxidation of organic materials in the pre-aeration tank unit of the Al- Muamirah WWTP [6].

The average of TSS concentration of raw influent was 202.73, but the average of TSS concentration of treated effluent was only 11.61. The TSS concentration of raw influent varied a lot (77 - 901), but the TSS concentration of treated effluent only changed a little (3 - 44) Over the course of one year as shown in (Table 5). The wastewater from the treatment plant goes into drainage A1 [7].

Table 5 . Removal efficiency for the major water quality parameters

Parameters	Mean Influent	Mean Effluent	Removal efficiency (%)
BOD_5	149.79	10.95	92.68
COD	229.97	48.36	78.97
TSS	202.73	11.61	94.27
T.N	14.71	5.5	62.61
PO_4	6.77	1.23	81.83
NH3	14.87	2.48	83.32
SO_4	899.46	821.07	8.71
NO_3	3.64	1.40	61.53
Cl	483.22	423.8	12.29
O&G	15.57	1.73	88.88

The TSS removal efficiency in the Al-Muamirah WWTP was excellent, coming in at 94.27%. BOD and COD are two of the most important biochemical parameters used to assess the quality of wastewater[8].

COD is the amount of oxygen required by a strong oxidant (such as H_2SO_4) to decompose both organic and inorganic substances in a water system [9]. Extreme oxygen depletion caused by elevated COD levels in water systems significantly affects aquatic life [10]. COD in the influent ranged from 98 mg/L to 893 mg/L, with an average of 229.97 mg/L. The

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average amount of COD left in the final effluent was 48.36 mg/L. This ranged from 10 mg/L to 89 mg/L (Table 4).

The BOD in raw water ranged from 75 to 573 mg/L with an average of 149.79 mg/L. The BOD concentration in the treated effluent varied between 4 and 49 mg/L with a mean concentration of 10.95 mg/L (Table 4).

The efficiency of BOD_5 removal was 92.68 % while the efficiency of COD removal was 78.97% from OCT (2020) to Aug (2021), which are given in Table (5).

3.2 Cluster Analysis

The outcome of cluster analysis was displayed as a tree diagram, where the period between two months relates to the similarity (similarity between two months in terms of treatment efficiency), so the shorter the distance, the better the group see Figure (2). Two major categories can be distinguished: the first consists of two subgroups the months with the highest processing efficiency in a plant (December 20, February 21, October 20, January 21, and November 20). In the second main group (from the left), the months (March 21, May 21, August 21, June 21, and April) representing the worse months in the plant's treatment efficiency that can be distinguished. It could be attributed to a number of variables, such as operational factors (on March 21, mechanical failure factor) that led to a decrease in processing efficiency at the facility due to without of maintenance. Months (December 20, February 21, October 20, January 21, and November 20) it is the best group in terms of processing efficiency as compared to the second group (March 21, May 21, August 21, June 21, July 21, and April 21)[11].

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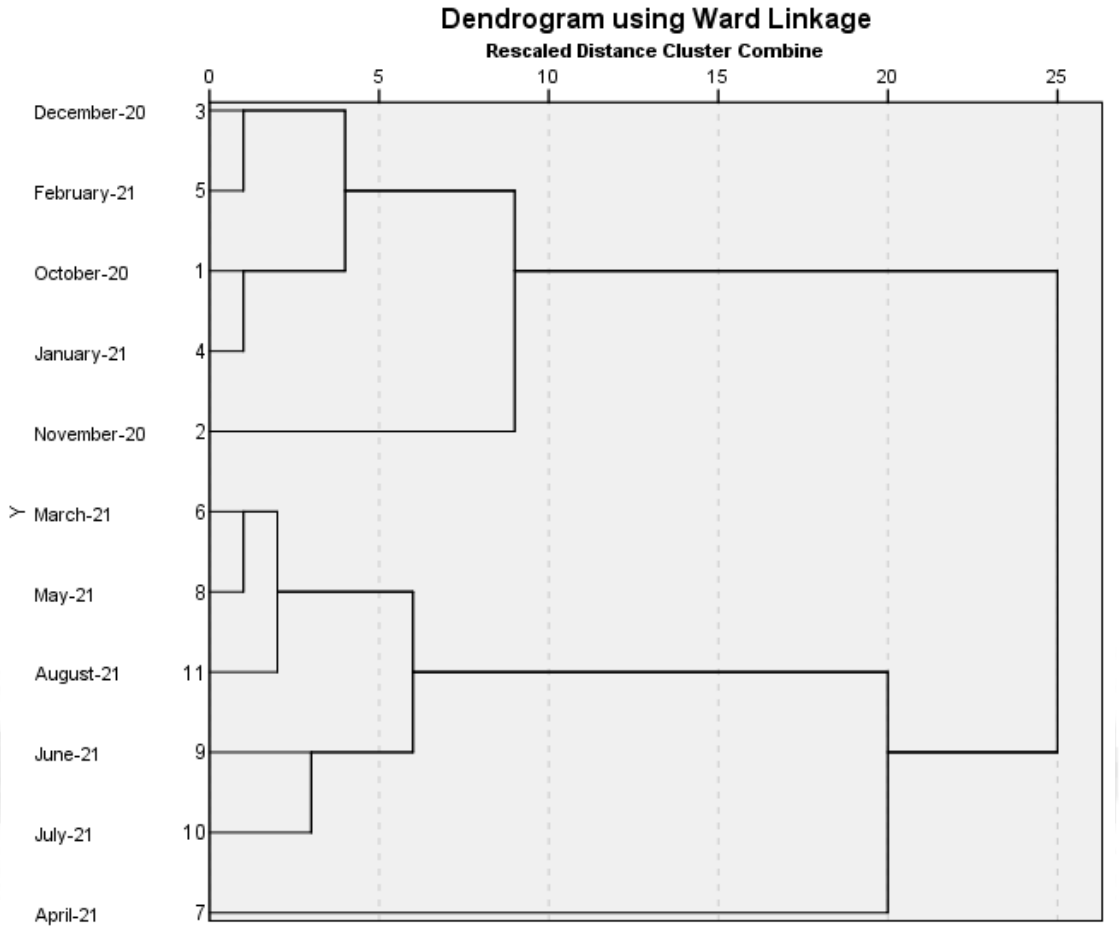

Figure (2): Clustering of months based on major water quality measures at Al Muamirah WWTP as depicted by a dendrogram

The dendrogram demonstrates in Figure (3) groups raw water quality parameters into three statistically significant clusters: cluster I correspond to BOD_5, TSS, NH_3, and O&G; cluster II comprises COD, PO_4, and TN; and cluster III is linked to SO_4, CL, and NO_3.Deduce from this Figure (3) there is a similarity between cluster I& cluster II in the removal efficiency of the elements. It was found that the worst efficiency of removing the elements in a cluster III.

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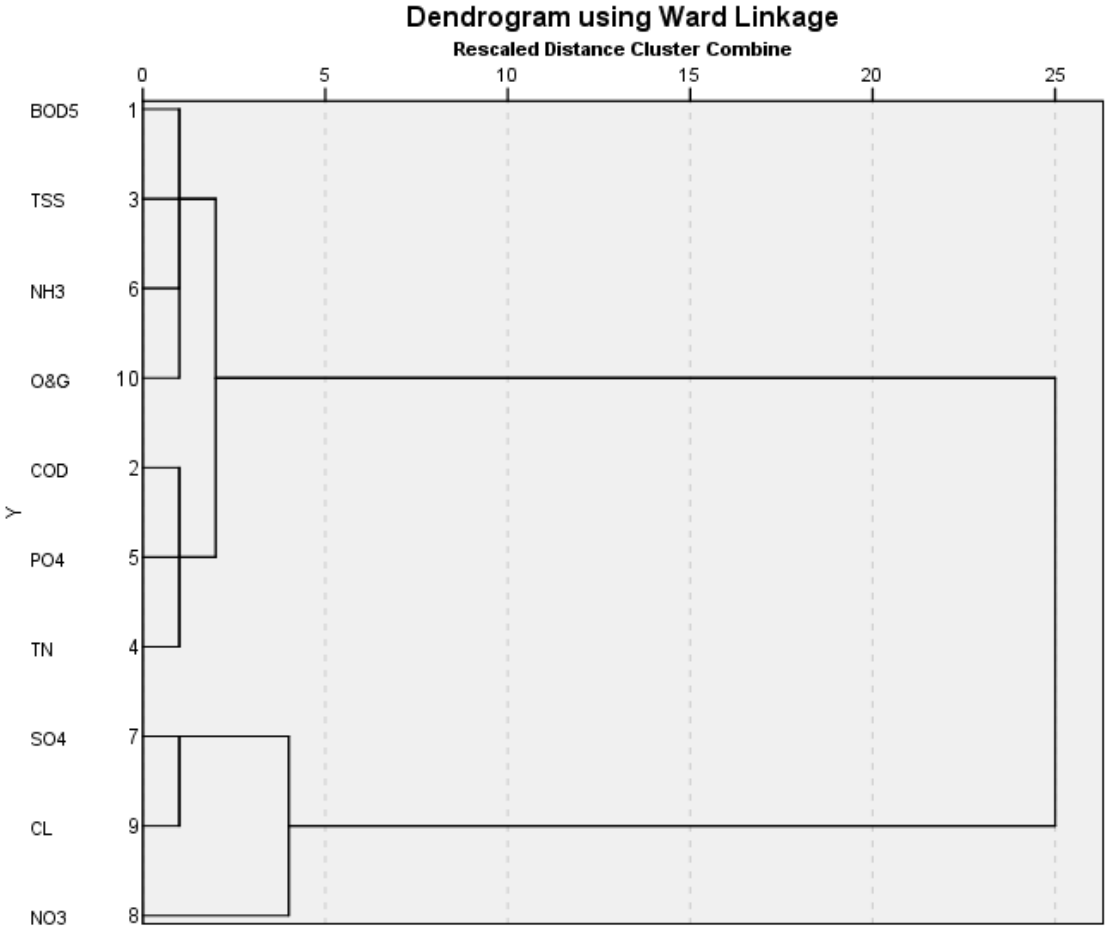

Figure (3): Dendrogram showing clustering of water quality parameters of Al Muamirah sewage treatment plant.

4. Conclusions

This study will be the initial step for determination of general characterization of domestic wastewaters of Hilla. The removal efficiency of TSS was found 94.27%. Therefore, the wastewater treatment units confirm that the TSS removal is significant throughout the wastewater processes. The removal efficiency of BOD was found to be more than 92.68% and that of COD was 78.97%. The treated wastewater effluent for Iraqi was designed to produce an average of final effluent quality of biological oxygen demand (BOD) and total suspended solids (TSS) as 20 and 30 mg/L, respectively to meet the Iraqi National Standards set by the Regulation 25 of 1967. This study indicates that Muamirah sewage treatment plant is capable of producing a good quality effluent with respect to BOD, COD And TSS but final effluent quality in SO_4&Cl does not meet the stringent regulations proposed by the Iraqi National Standards set by the Regulation 25 of 1967. Cluster analysis shows that months (December20, February21, October20, January21 and November20) indicate a good level of treatment compared to that of (March21, May21, August21, Jun21, July21 and April21).

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تقييم أداء محطة معالجة المعميرة للمياه الصرف الصحي باستخدام التحليل الاحصائي في مدينة الحلة، العراق

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الخلاصة

اعتمد التقييم على بيانات تشغيل المحطة مثل BOD_5 ، COD، TSS، T.N، PO_4 ، NH_3 ، SO_4 ، NO_3 ، Cl، والزيوت والدهون لفترة 11 شهرًا من أكتوبر (2020) إلى أغسطس (2021). البيانات مأخوذة من مختبر في محطة معالجة مياه الصرف الصحي وتم تجميعها في برنامج Excel. أظهرت النتائج أن كفاءة إزالة BoD_5 ، COD، TSS، T.N، PO_4 ، NH_3 ، SO_4 ، NO_3 ، CL، O&G كانت 92.68٪ ، 78.97٪ ، 94.27٪ ، 62.61٪ ، 81.83٪ ، 83.32٪ ، 8.71٪ و 61.53٪ و 12.29٪ و 88.88٪ على التوالي على أساس شهري. بناءً على ذلك ، يمكن التوصية بأن يكون لمحطة معالجة مياه الصرف الصحي المعميرة كفاءة مقبولة باستثناء كفاءة الكبريتات والكلوريدات غير المقبولة ، يرجى معالجتها في المستقبل. تمت تجربة تقنية إحصائية متعددة المتغيرات للبيانات من خلال تطبيق التحليل العنقودي باستخدام الإحصاء .(SPSS) يُظهر التحليل العنقودي أن الأشهر (20 ديسمبر، 21 فبراير، 20 أكتوبر، 21 يناير، 20 نوفمبر) تشير إلى مستوى جيد من العلاج مقارنةً ب (21 مارس، 21 مايو ، 21 أغسطس ، 21 يونيو ، 21 يوليو ، 21 أبريل).

الكلمات الدالة: الكفاءة، التحليل العنقودي، الأشهر، محطة معالجة مياه الصرف الصحي.

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