STATISTICAL ANALYSIS OF QUALITY PARAMETERS OF MAAMERA SEWAGE TREATMENT PLANT

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Abstract
The present study aimed to statistical analysis of quality parameters of Maamera sewage treatment plant at Hilla city. The plant designed to serve 50000 populations and it is operating on biological treatment method(Activated Sludge Process) with an average wastewater inflow of 12000 M^3D. Wastewater data were collected yearly by Mayoralty of Hilla from the influent and effluent in Maamera Sewage treatment plant for major water quality parameters, such as biological oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), pH, T, chloride (Cl) over a period of six consecutive years. performance efficiency of the plant has been estimated for each year. A multivariate statistical technique of the data has been attempted by applying Cluster analysis using Statistical Package for Social Sciences (SPSS). The result reveals that the overall performance of the existing was satisfactory. Cluster analysis shows that years (2009, 2010 , 2011 and 2012) indicate a good level of treatment compared to that compared to that of 2007 and 2008. Final effluent quality(in term of mean value of six consecutive years) does not meet the stringent regulations proposed by the Iraqi National Standards set by the Regulation 25 of 1967. The BOD_5/COD ratio of the influent was calculated as 0.49 in total wastewater.

Keywords: Maamera sewage treatment plant, Cluster analysis, Statistical analysis.

التحليل الإحصائي للمتغيرات البيئية في محطة المعيمرة لمعالجة مياه الصرف الصحي

الخلاصة
تهدف هذه الدراسة إلى التحليل الإحصائي للمتغيرات البيئية في محطة المعيميرة لمعالجة مياه الصرف الصحي في بابل. صممت المحطة لتخدم (50000) نسمة من السكان كما تعمل على الطريقة البيولوجية (طريقة الحمأة المنشطة) مع معدل جريان (12000) م^3 / يوم. تم جمع البيانات سنويا من دائرة مجاري بابل للماء الخام والماء المعالج في محطة المعيميره للمتغيرا ت الأساسية لنوعية المياه وهي المطلب الحيوي للأوكسجين, المطلب الكيمياوي للأوكسجين, المواد الصلبة العالقة , pH , درجة حرارة و الكلوريدات على مدى ست سنوات متتالية. وتم حساب كفاءة ال محطة في كل سنة. كما تم أستخدام التحليل المتعدد للمتغيرا ت عن طريق تطبيق التحليل العنقودي باستخدام برنامج (SPSS). أظهرت النتائج بأن المحطة تعمل بكفاءة مقبولة. وأظهر التحليل العنقودي بأن السنين (2012,2011,2010,2009) تشير الى وجود مستوى جيد من المعالجة إذا ماقورنت بالسنين (2007, 2008). أن وجود المياه للماء المعالج (متوسط القيم لستة سنوات متتالية) لاتلائم الضوابط الصارمة التي اقترحتها المعايير الوطنية العراقية التي وظعنها المادة (25) من عام (1967). تم حساب (BOD_5 /COD) للماء الخام وكانت (0.49) في مياه الصرف الصحي.

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Introduction

Wastewater is essentially the water supply of the community after it has been fouled by a variety of uses. The water supplied to a community receives a range of chemical substances during its use such that the wastewater acquires a polluting potential and becomes a health and environmental hazard. Communicable diseases of the intestinal tract such as cholera, typhoid, dysenteries and water borne diseases like infectious hepatitis etc., can be spread from uncontrolled disposal of wastewater, and therefore prevention of communicable diseases and protecting public health attracts the primary objective of sanitary wastewater disposal[k. Sundara Kumar. et al.,2010]. There are one main wastewater treatment plants were built within Hilla city. Al-Maamera sewage treatment plant is one of these plants and has begun to operate in 1982. the plant works with an activated sludge system which biologically treats compounds of carbon and nitrogen in raw wastewaters. Maamera sewage treatment plant serve 50000 populations and the treatment facility is a conventional activated sludge system with an average wastewater inflow of 12000 M^3D. The sewerage system is designed to accommodate the industrial wastewater, as well as domestic effluent. The treated wastewater in the plant is then being discharged to Shatt Al-Hilla River. A full outline of the plant units is shown in Fig. 1.

Fig. (1): Image map of Maamera sewage treatment plant, Hilla (Al-Maamera project office, 2012*)*

Table (1): Locations name of Al-Maamera project.

No. Location	Location name
1	Sediment tanks
2	Reaeration tanks
3	Primary stage
4	Office storages
5	Dilution tanks
6	New dilution tanks
7	New reaeration tanks
8	Final stage
9	Storage tanks
10	Pump sediment stage
11	New sediment tanks
12	Compact unit station

Methods

1. Data collection

In the present study, certain data have been collected yearly by the Mayoralty of Hilla from the influent and effluent in Maamera sewage treatment plant. Major water quality parameters were selected for this study; biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), PH, T, chloride (Cl) over a period of six consecutive years.

2. Wastewater samples

Composite samples of influent and effluent of Maamera sewage treatment plant were adopted on daily basis in jars of one liter each and preserved at 4 ℃ during transporting to the laboratory. All analyses were performed immediately after arrival to laboratory.

3.Sample analysis

In this experimental study; COD, BOD_5, TSS, pH , T and Chloride parameters were analyzed. All measurements were conducted following the standard methods for the examination of wastewater[APHA et al., 1998]. Most of the analyses were carried out by the staff of the central laboratory of Maamera sewage treatment plant and result were rendered available upon the authors request while other analyses were carried out in chemical laboratory, water resource techniques department, institute of technology.

Statistical Analyses

Means, maximum values, minimum values and standard deviations of parameters selected in this study during six years were calculated using SPSS18. A multivariate statistical technique of the data has been attempted by applying Cluster analysis using SPSS. Cluster analysis is efficient ways of displaying complex relationships among many years[Singh, K. P. et al., 2004]. The term cluster analysis encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories. In other words cluster analysis is an exploratory data analysis tool which aims at sorting different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise. Euclidean distance method was used for determining distance. This is probably the most commonly chosen type of distance. It simply is the geometric distance in the multidimensional space and is computed as:

$$Distance(X,Y)=\{\Sigma i(Xi-Yi)^2\}^{1/2} \quad (1)$$

In this study cluster analysis was done using SPSS package. Generally, it is good practice to transform the dimensions so they have similar scales [Mahloch JL.,1974] [Das and Acharya., 2003].

1.Removal Efficiency

The effectiveness of removal of TSS,BOD and COD was calculated using the following formula:

$$\% \text{ Removal efficiency of } P=(P\text{inf} - P\text{eff}) / P\text{in} \times 100 \quad (2)$$

Where , *P* is the selected parameter, *P*inf is the mean influent and *P*eff is the mean effluent.

Results and Discussion

The evaluation of performance efficiency of the plant was undertaken in terms of effluent quality. The variations in the raw wastewater characteristics with time are illustrated graphically in Fig(2) . The results of the physicochemical parameters of the final effluent are presented in Fig. 3. To characterize the quality of waste water averages, standard deviations as well as maximum and minimum values were calculated for the selected parameters from the data, descriptive statistics for the water quality data of the plant are given in table 2.

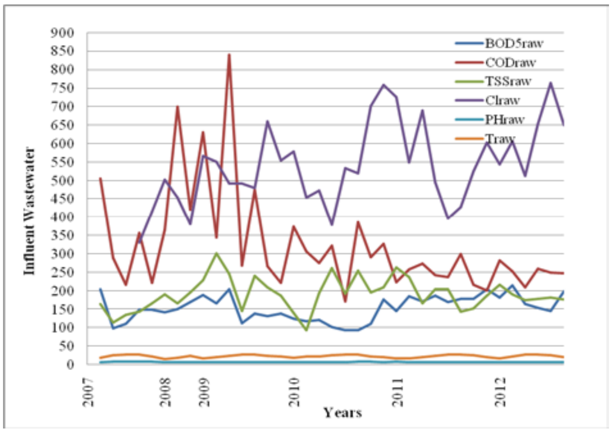


Fig. (2): Variations in the raw wastewater (influent) characteristics over six years

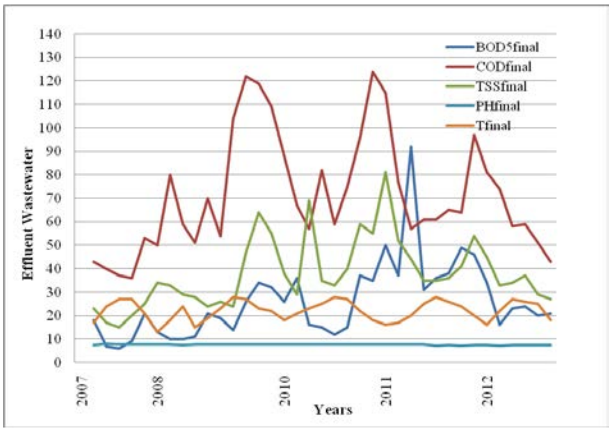


Fig. (3): Yearly variations in the wastewater characteristics of final effluent in Maamera sewage treatment plant

Table (2): Descriptive statistics for the water quality data of Maamera sewage treatment plant

Parameters	Years	Influent					Effluent				
		Min	Max	Mean	St.Dv	N	Min	Max	Mean	St.Dv	N
BOD_5	6	5	552	156.84	69.82	753	0	170	26.06	22.49	761
COD	6	63	1406	324.55	205.35	250	14	381	71.04	39.23	252
TSS	6	16	1143	190.38	117.65	859	3	373	37.66	23.12	869
Cl	6	319	1106	549.44	143.56	126	312	809	505.8	115.72	126
PH	6	4.7	8.7	7.52	0.35	861	5.7	10	7.58	0.30	869
T	6	9	34	23.05	3.84	854	7	31	22.25	4.35	858

The composition of wastewater effluent varies from facility according to level of treatment, type of households, businesses, industries, and public facilities discharging into the system and this could be an important contributory factor to the observed differences in pH. The pH level of a water system determines its usefulness for a variety of purposes. Very high or low pH has been reported [Morrison,G. et al., 2001] to be toxic to aquatic life and alter the solubility of other chemical pollutants as well as some essential elements in water systems, thereby causing adverse effects on the ecosystem and those who depend on it. The European Union tolerance limit for PH in water for the support of fisheries and aquatic life is also set at 6-9 units [Chapman., 1996].

Generally, pH values of the influent and the effluent were slightly alkaline(Mean value) ranging from 4.7 to 8.7 and from 5.7 to 10, with a mean value 7.52, 7.58 respectively during the period of the study (Table 2). The increase in effluent PH compared to influent PH is attributed to the decrease in dissolved CO2 concentration through a reduction in the concentration of organic matter due to oxidation during the pre-aeration tank unit existing in the Maamera sewage treatment plant[Colmenarejoa, M.F. et al., 2006].

TSS is a very important variable in wastewater discharge control. A part from being source of aesthetic nuisance along river bank, TSS causes havoc in irrigation systems where in form of algae can block pipes, sprinklers, emitters and narrow water channels. TSS can also adsorb heavy metals unto their surfaces and thereby facilitating formation of heavy metal complexes [Nkegbe, E . et al., 2005]. By this an effluent high in TSS can become an easy vehicle for the introduction of heavy metals to the environment.

Means of TSS concentration of raw influent were 190.38 while means of TSS of treated effluent were found to sharply decline to 37.66. Although TSS concentration of raw influent had a great variations (between 16 and 1143), a small variations was observed in TSS concentration of treated effluent (between 3 and 373) during the four years (Table 2) which implies that the performance of Maamera sewage treatment plant is independent on the influent characteristics. The treatment plant discharges its effluent into Shatt Al-Hilla River. High TSS can cause reduction in sunlight intensity in water bodies and reduce primary productivity especially on green algae. This is can disturb the aquatic food chain. Less light can also effect temperature in the aquatic environment impacting negatively on primary and secondary productivity of aquatic life and temperature stratification of the system. TSS can also be a source of organic decay that can release nauseating orders [Nkegbe, E . et al., 2005].

The removal efficiency for the TSS during the period of data collection from 2007 to 2012 is given in Table 2. Al-Maamera sewage treatment plant achieved good removal efficiency of TSS ranged from 75.72% to 86.24% during six years as shown in Fig 4.

Biological oxygen demand (BOD) and Chemical oxygen demand (COD) are two of the most important biochemical parameters commonly used to examine wastewater quality since they reflect the organic load in wastewater[Huertasa, E. et al., 2008].

COD is a measure of the amount of oxygen required by a strong oxidant (e.g., H_2SO_4) to break down both organic and inorganic matters in a water system [Akan,J.C et al., 2008]. Elevated levels of COD in water systems lead to drastic oxygen depletion which adversely affects aquatic biota [Fatoki, S. O., et al., 2003].

In the influent , the Chemical Oxygen Demand (COD) ranged from 63 to 1406 mg/L with a mean value of 324.55 mg/L. while the residual COD in final effluent ranged from a minimum value of 14 mg/L to a maximum value of 381 mg/L, with a mean value of 71.04 mg/L (Table 2).
The corresponding Biological Oxygen Demand (BOD) in raw water ranged from 5 to 552 mg/L, with a mean value of 156.84 mg/L. The BOD concentration in the treated effluent ranged from 0 to 170 mg/L, with a mean value of 26.06 mg/L(Table 2).

Table (3): Removal efficiency for the major water quality parameters

Years	Parameters	Mean Influent	Mean Effluent	Removal efficiency(%)
2007	BOD_5	142.07	12.36	91.30
	COD	311	41.43	86.67
	TSS	144.25	19.84	86.24
2008	BOD_5	155	11.06	92.86
	COD	497.25	63.45	87.23
	TSS	185.07	31.90	82.76
2009	BOD_5	153.54	22.21	85.53
	COD	412.41	89.20	78.37
	TSS	222.58	38.56	82.67
2010	BOD_5	116.87	22.8	80.49
	COD	307.50	84.76	72.43
	TSS	202.40	47.29	76.63
2011	BOD_5	179.05	48.26	73.04
	COD	246.33	72.04	70.75
	TSS	189.45	45.98	75.72
2012	BOD_5	176.04	23.39	86.71
	COD	247.82	59.73	75.89
	TSS	185.94	33.83	81.80

Efficiency of BOD_5 removal was 91.30, 92.86, 85.53, 80.49 , 73.04 and 86.71% while efficiency of COD removal was 86.67 , 87.23, 78.37, 72.43 , 70.75 and 75.89% in 2007, 2008, 2009, 2010 , 2011 and 2012 respectively (Fig.4).

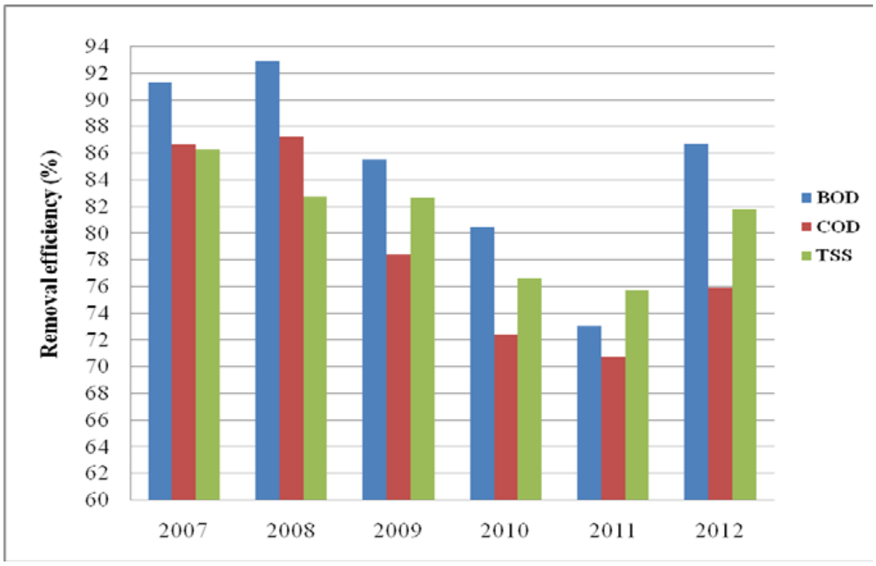
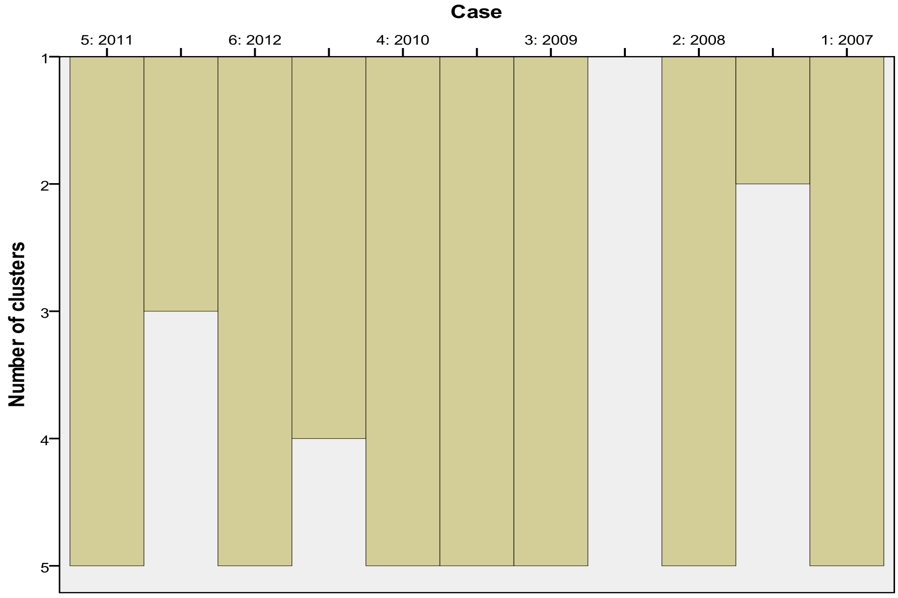


Fig. (4): Removal efficiency of the selected parameters of effluent in Maamera sewage treatment plant

The BOD/COD ratio has been reported as indicator for biodegradation capacity [Metcalf and Eddy., 1985]. If BOD/COD ratio is more than 0.5, biodegradation will readily take place, if between 0.2 and 0.4 biodegradation will occur only in favorable thermal situation and if the ratio is below 0.2 biodegradation will not proceed [Contreras, S., M. et al., 2003]. It was found that domestic wastewater has typically a BOD/COD ratio between 0.4 and 0.8 [Metcalf and Eddy., 1985] and as reference, a BOD/COD ratio of 0.4 is generally considered the cut-off point between biodegradable and nor biodegradable waste [Turak and Afsar., 2004]. In the study, BOD/COD ratio in raw influent was around 0.49, which indicate the presence of considerable amount of organic materials vulnerable to biodegradability.
The overall efficiency of the Maamera sewage treatment plant for removing the BOD, COD and TSS was considered good. A removal of more than 87 %, 76 % and 82% was achieved for BOD,COD and TSS respectively.
The increase in effluent Cl compared to influent Cl is attributed to the chemical treatment part in the plant due to chlorination process in the last stage of treatment in the Maamera sewage treatment plant.

1. Cluster Analysis

The output result of cluster analysis has shown as a dendogram, where the distance between two years corresponds to the similarity and dissimilarity between two years (similarity between two years in term of treatment efficiency), i.e. greater will be the distance, lesser will be the similarity (Figure 5). Two main clusters can be observed: the first of them includes two tight subgroups which represent years(2009 , 2010, 2011 and 2012)which are characterized by the most efficient years in term of treatment efficiency of the plant. In the second main cluster(from the left): one significantly different group can be seen and is constituted by years (2007 and 2008), which showing the worst years in term of treatment efficiency of the plant. It may be due to different factors like operational factor (in 2007, mechanical failure factor) many mechanical failures occurs in the plant with no maintenance which led to less efficiency for the treatment process). Years(2009 , 2010, 2011 and 2012) indicate a good level of treatment compared to that of (2007 and 2008) .



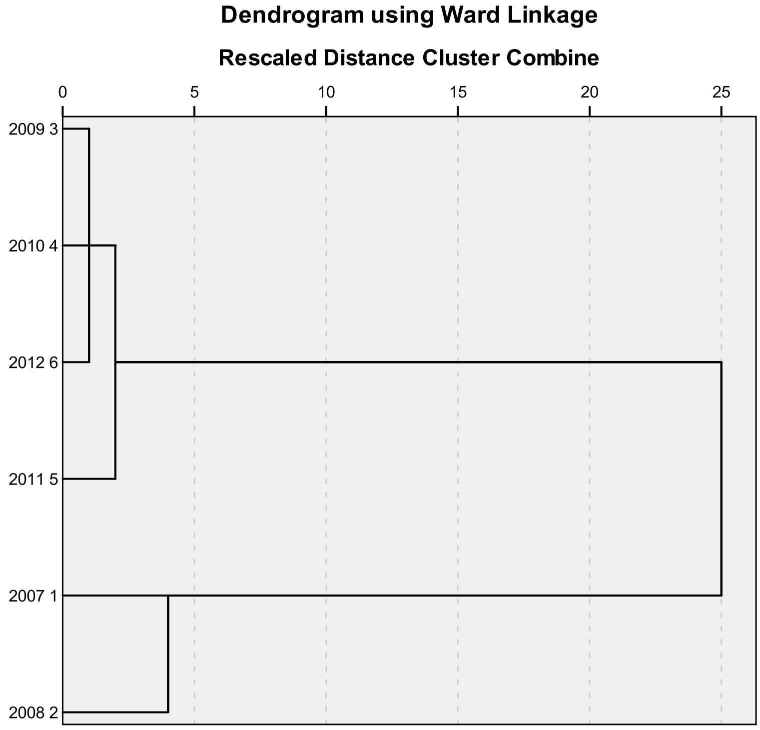


Fig. (5): Dendogram showing clustering of years according to major water quality parameters of Maamera sewage treatment plant (The axis shown at the top indicates the relative similarity of different cluster groups. Lesser distance corresponds to greater similarity between years)

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 to be more than 82%. 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 87% and that of COD was 76%. The overall performance of the existing was satisfactory.
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 Maamera sewage treatment plant is capable of producing a good quality effluent with respect to BOD, COD And TSS but final effluent quality in term of mean value of six consecutive years does not meet the stringent regulations proposed by the Iraqi National Standards set by the Regulation 25 of 1967. Cluster analysis shows that years (2009 , 2010, 2011 and 2012)indicate a good level of treatment compared to that of (2007 and 2008).

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