



EFFLUENT QUALITY ASSESSMENT OF AL-DIWANIYAH SEWAGE TREATMENT PLANT BASED ON WASTEWATER QUALITY INDEX

Dr. Basim Hussein Khudair

Assistant Professor, University of Baghdad/ Engineering College, Iraq

Dr. Ahmed Makki AL-Sulaimen

Lecture, University of Qadisyah/ Engineering College, Iraq

Rehab Karim Jbbar

Assistant Lecturer, University of Baghdad/ Engineering College, Iraq

ABSTRACT

Treated effluent wastewater is considered an alternative water resource which can provide an important contribution for using it in different purposes, so, the wastewater quality is very important for knowing its suitability for different uses before discharging it into fresh water ecosystems. The wastewater quality index (WWQI) may be considered as a useful and effective tool to assess wastewater quality by indicating one value representing the overall characteristic of the wastewater. It could be used to indicate the suitability of wastewater for different uses in water quality management and decision making. The present study was conducted to evaluate the Al-Diwaniyah sewage treatment plant (STP) effluent quality based on wastewater quality index (WWQI) for disposal according to Iraqi limitations. Wastewater samples were collected from Al-Diwaniyah STP during 2012-2016 and tested for a comprehensive analysis of physical and chemical analysis. The parameters included Total suspended solids (TSS), Nitrate (NO_3), Biological oxygen demand (BOD_5), and Chemical oxygen demand (COD). The determination of the WWQI was done using the weighted arithmetic method. The results showed that the effluent BOD_5 , COD and TSS concentrations were not in the Iraqi standards for effluent disposal. The WWQI of this effluent classified its quality within ranged from poor to very poor according to Iraqi standards (IQS) and very poor to very polluted under the world health standards (WHO), that could cause environmental pollution in the receiving river. The permanent solution is through the proper operation using scientific methods and training the operational staff using technical methods and then future solution, advanced treatment in the plant, by completing both the solutions above will lead to upgrade the effluent quality to achieve the required water standards.

Key words: Effluent quality assessment, Sewage treatment plant, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Total dissolved solids (TDS), Wastewater Quality Index (WWQI)

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1. INTRODUCTION

The wastewater treatment plants performance efficiency based on institutional, social, economic and technical considerations. Many pollution problems appear from the disposal of wastewater (treated) and untreated (about 80%) into water resources [17]. Most communities have not given much attention to wastewater treatment processes because of the lack of knowledge in health risks of wastewater [11]. Wastewater characterization has become a very significant parameter in water management process due to the flocculation in wastewater characteristics. In a typical wastewater treatment system, the primary treatment phase is designed to remove suspended solids using gravitational settling, flotation, and sedimentation, and the secondary treatment phase (biological treatment) is for the degradation of organic matter. The quality of the treated wastewater is very important for reuse and disposal into water resources by the application of environmental limitations of wastewater effluents that will reduce and control the pollution load [10].

Many water quality indicators have been developed around the world, which can easily judge, decision-making and help in water management within a particular area quickly and efficiently using wastewater quality index WWQI [1, 8, and 13]. It is possible to calculate the WWQI after every treatment stage so that the optimization in every succeeding process can be introduced. The resource optimization on waste water treatment is very essential and display of WWQI at respective locations will be helpful for better operations on the treatment plant [15]. The wastewater quality index (WWQI) concept was developed to facilitate understanding of its quality by being a numerical value. e. 100 (poor) to 0 (excellent) [20]. WWQI has become an important decision-making tool for authorities and easy to understand for common people [5]. The objective of this paper is to evaluate the quality of the effluent from Al-Diwaniyah STP before discharging into the environment using wastewater quality index (WWQI) as a decision-making indicator.

2. MATERIALS AND METHODS

2.1. Study Area Description

Al-Diwaniyah sewage treatment plant (STP) is location on road 8 south of Al-Diwaniyah Governorate on Shut Al-Diwaniyah, a branch of the Euphrates River, southern part of Iraq as shown in Fig. 1. The design capacity of this plant is 4DWF (dry weather flow) which is 80000 m³/day. The plant consists of two identical streamlines to treat the sewage in two stages, primary and secondary treatment processes [14]. The primary stage consists of a rack screen and the Detritors for the sedimentation of inorganic suspended solids. The secondary treatment is an activated sludge process for the biological degradation of the organic content. The effluent from the primary treatment enters a distribution chamber that receives the return sludge from the secondary sedimentation tank. The mixture from this chamber is distributed to the aeration tanks of the two streams. The secondary sedimentation tank effluents flow to the chlorine contact tank for disinfection before being discharged into receiving water. The

holding tank receives the sludge waste from secondary clarifiers with return supernatant to the STP's head and the settled sludge to the drying beds. The plant is designed to yield an effluent of 20 mg/L BOD₅ and 30 mg/L suspended solids.



Figure 1 Google earth photo for Al-Diwaniyah WWTP, Diwaniyah project, Iraq.

2.2. Data Collection and Analysis

This study analyzes the quality of the raw wastewater (influent) and treated wastewater (effluent) of Al-Diwaniyah sewage treatment plant (STP). The collection and experimental data used in this study were provided from Ministry of Health and the Environment, Ministry of Construction and Housing and Public municipalities and Al-Diwaniyah STP office for the period between 2012 until 2016, as minimum, average and maximum values for influent and effluent, as shown in Table 1. The data collected through the study period that represented three samples for each parameter as daily and monthly average values for each parameter, as pH, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD₅), dissolved oxygen (DO) and nitrate (NO₃).

Table 1 Annual average influent and effluent concentrations from 2012-2016.

Parameter	Influent			Effluent		
	Min	Max	Average	Min	Max	Average
pH	5.73	9.77	7.75	6	8.5	7.8
TSS (mg/L)	202.6	365.2	251.5	49.9	131.7	81.5
COD (mg/L)	326.1	498.7	415.6	76.6	225.7	129.2
BOD (mg/L)	169.1	265.8	211.8	23.7	135.1	82.3
DO (mg/L)	2.3	11	6.6	2.3	9.7	4.4
NO ₃ (mg/L)	25.7	40.3	32.7	11.4	21	15.7

3. WASTEWATER QUALITY INDEX

Wastewater Quality Index (WWQI) is a unit less number ranging within 0 to 100 that describes a quality value to an aggregated set of measured physical, chemical, and biological parameters and to indicate an overall characteristic of wastewater [19]. This index helps to have a competent model to optimize the treatment processes and to evaluate the validity of the treated wastewater (effluent) for disposal and reuse for irrigation.

In this study, WWQI of the Al-Diwaniyah STP was determined using the weighted arithmetic method based on the six parameters of effluent compared with the specification and standards for effluent disposal to the river, which must not exceed the limitation listed

according to Iraqi effluent standards (IQS) [18,21]. Table 2 shows the procedure used to calculate the WWQI.

Table 2 Sample of calculation of the wastewater quality index.

Parameters	Ci	Si (IQS)	Wi	qi	Wi*qi
pH	7.8	7.5	0.13	104	13.87
TSS (mg/L)	81.5	60	0.02	135.83	2.26
COD (mg/L)	129.2	100	0.01	129.2	1.29
BOD (mg/L)	82.3	40	0.03	205.75	5.14
DO (mg/L)	4.4	4	0.25	110	27.50
NO ₃ (mg/L)	15.7	50	0.02	31.4	0.63
Total			0.46		50.69
Overall WWQI					111.4161

Where:

Ci= concentration of water parameter.

Si= standard values according IQS.

Wi= 1/Si

qi= quality rating scale for each parameter; $100 * (Ci / Wi)$

Table 3 was used to classify the effluent quality according to the calculated WWQI of Al-Diwaniyah STP effluent, where the wastewater was categorized in to six groups ranging from excellent water to very polluted water.

Table 3. Water Quality Classification based on WWQI value [3].

WWQI Value	Water Quality
<50	Excellent
50 - 100	Good
100 - 200	Poor
200 - 300	Very Poor
300 - 400	Polluted
>400	Very Polluted

4. RESULTS AND DISCUSSION

Pollution of water resources resulting from the direct disposal of untreated sewage which considered one of the most important environmental problem in developing countries due to the lack of expertise of the technical staff and the financial and administrative problems that facilitate proper operation and regular maintenance in waste water treatment plants [16].

4.1. Influent and Effluent Quality Assessment

The average monthly concentrations of pH, TSS, COD, BOD₅, DO and NO₃ in the influent and effluent flow are shown in Table 1. The strength of the wastewater entering the plant varied from medium to high according to Table 4. Fig. 2 was plotted between each average concentration influent and effluent parameter with time (year) during study period 2012-2016. The average annual concentration of influent sewage TSS, COD, BOD₅, and NO₃ were 305, 428, 229 and 30 mg/L and for effluent 92, 134, 80, 18 mg/L, respectively. The effluent concentrations of TSS, COD, and BOD₅ were higher than the Iraqi effluent standards of 60,

100, and 40 mg/L respectively. The effluent concentrations exceeded the effluent standards over the period of the study and that could be due to operational problems in the biological treatment stage. Results showed that BOD₅ and COD have the differ trend in some cases, may be due to the large variable results throughout the duration of the study, but should be matched by a high rate [6].

Table 4 Strength classification of Untreated Sewage [12].

Parameter	Strength		
	Low	Medium	High
BOD ₅ mg/L	100	200	400
COD mg/L	175	300	600
TOC mg/L	100	200	400

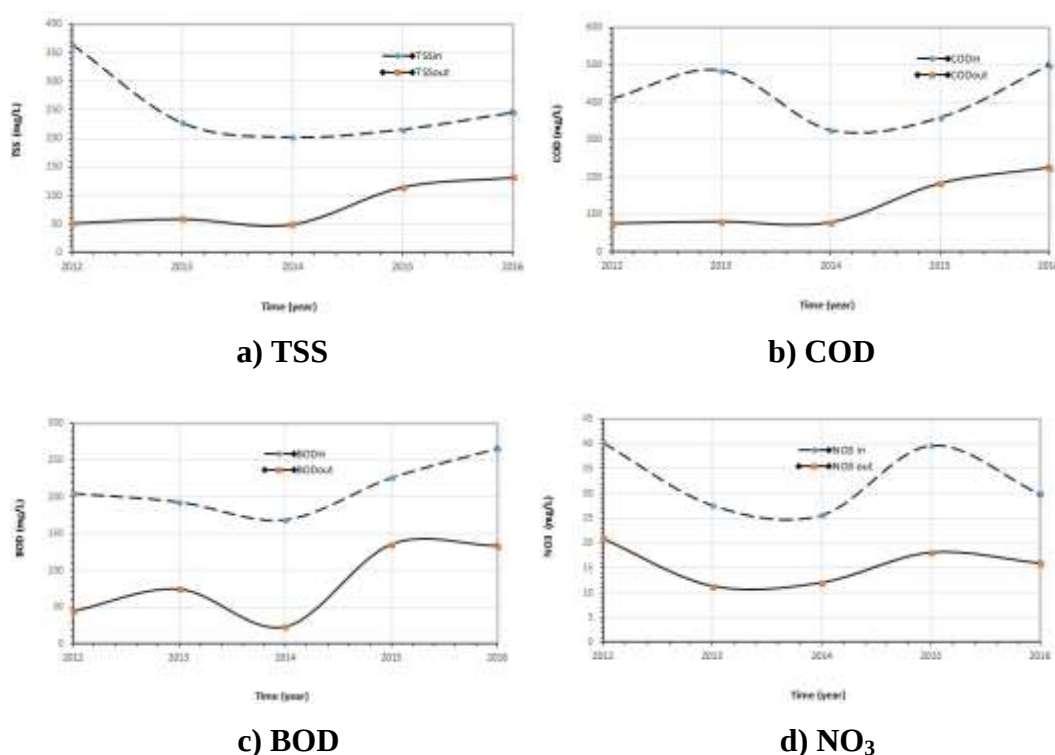


Figure 2 Influent and Effluent characteristic variation during 2012-2016.

4.2. BOD₅/COD RATIO

Typical values of BOD₅/COD ratio for untreated municipal wastewater are in the range of 0.3 to 0.8 as shown in Table 5. If the ratio is 0.5 and above, waste is easily treatable by biological means. If the ratio is less than 0.3, some toxic components or adapted microorganisms may be needed for degradation. This ratio decreases to 0.1-0.3 for the treated sewage [12]. Table 6 shows the daily samples for BOD₅/COD ratios of the influent sewage with 301 samples during 2012-2016. This ratio ranged from 0.22-1.25 with an average of 0.58 and variance 0.05, these values confirm with the typical ratios for the untreated sewage. For the effluent, the BOD₅/COD ratios ranged from 0.17-1.73 with an average of 0.62 and variance 0.03. The high concentrations of BOD₅ and COD in the effluent gave high BOD₅ /COD ratios that did not confirm with the typical values for the treated sewage this indicates that the wastewater needs more treatment.

The BOD_5/COD ratio remains practically constant, after anaerobic treatment of the wastewater. This type treatment plays a very important role in the performance of the whole treatment system, since it efficiently removes chemical and biological material maintaining. There is usually no correlation between BOD_5 and COD in wastewater with slowly biodegradable organic suspended solids and in complex waste effluents containing refractory substances [9], while in some researchers have same trend [6]. Thus, treated effluents may exert virtually no BOD_5 and yet exhibit a substantial COD (where COD represents all organic matter, either partially degradable or non-biodegradable and BOD_5 represents the biodegradable matter only).

Table 5 Various parameters ratios used for wastewater characterization [12].

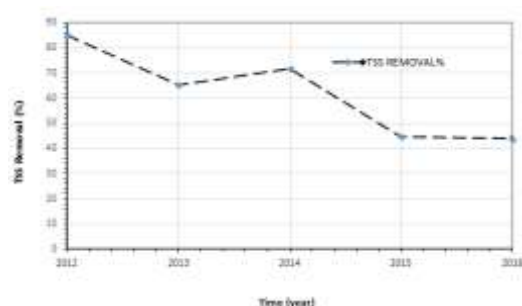
Type of wastewater	BOD_5/COD	BOD_5/TOC
Untreated	0.3-0.8	1.2-2.0
After primary settlement	0.4-0.6	0.8-1.2
Final effluent	0.1-0.3	0.2-0.5

Table 6 Average monthly BOD_5/COD ratio of Al-Diwaniyah STP.

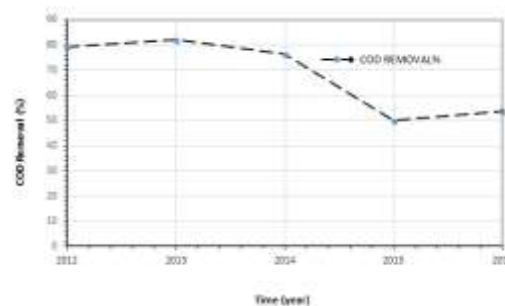
Parameter	Influent			Effluent		
	Min	Max	Average	Min	Max	Average
2012	0.23	1.79	0.54	0.18	2.79	0.71
2013	0.27	0.79	0.46	0.19	0.81	0.49
2014	0.19	1.67	0.58	0.07	1.06	0.40
2015	0.08	1.00	0.71	0.17	2.43	0.84
2016	0.33	1.00	0.60	0.22	1.57	0.68
Average	0.22	1.25	0.58	0.17	1.73	0.62

4.3. Al-Diwaniyah STP Overall removal Efficiency

Al-Diwaniyah STP is designed for the biological treatment of the organic matter represented by BOD_5 or COD reduction and not for dissolved matter. Fig. 3 shows the overall removal efficiency TSS, COD, BOD_5 and NO_3 reduction at the Al-Diwaniyah STP were low, 62.2%, 68.33%, 62.72% and 53.23% respectively during study period 2012-2016. This is due to the lack of adoption of modern technical methods in the wastewater management through the training and development of the operational staff to manage all units in the plant. This may require adopting a maintenance program of equipment and training of the staff to handle all technical problems in the plant.



a) TSS



b) COD

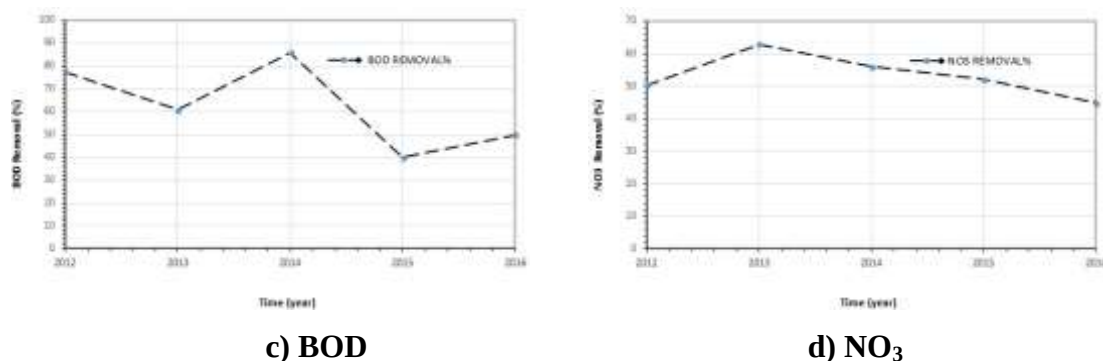


Figure 3 Overall removal efficiency variation during 2012-2016.

4.4. Wastewater Quality Index Assessment

Fig. 4 shows the wastewater quality index (WWQI) variation of Al-Diwaniyah STP during the period 2012-2016. The monthly variation of WWQI values indicates that the effluent quality is within the category of poor to very poor water according to the Iraqi standards and within the category of very poor to very polluted according to the World Health Standard as shown in Fig.4-a. The annual variation of the WWQI values of the effluent is classified as poor according to according to Iraqi standards and polluted to very polluted under the World Health Standards as shown in Fig. 4-b. These results indicate the inefficient removal efficiency of the plant and its contribution to increase the organic and inorganic contamination to the receiving surface water [2].

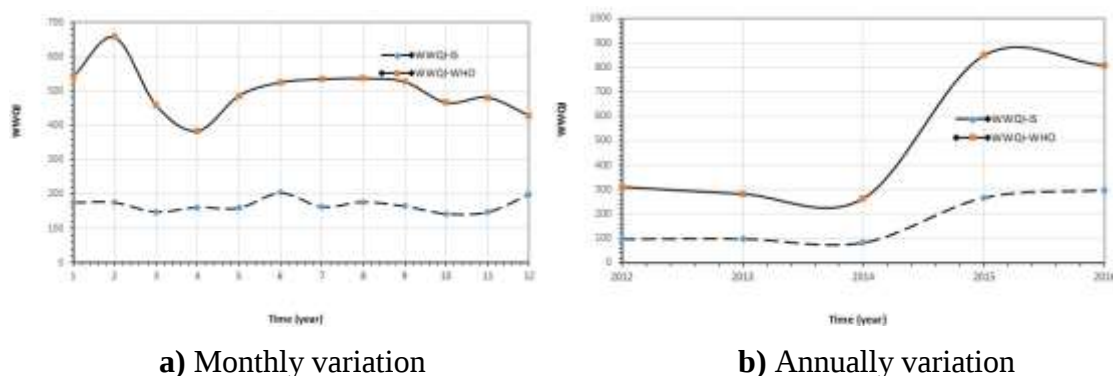


Figure 4 WWQI variation during 2012-2016.

Table 7 shows the WWQI classification of Al-Diwaniyah STP effluent during the study period 2012-2016 according to Iraqi standards and WHO specifications. In general, the results indicate that the treated effluent wastewater of Al-Diwaniyah STP is ranged from poor to very poor according to Iraqi standards (IQS) and very poor to very polluted under the world health standards (WHO), which reflects the incomplete treatment of wastewater at the primary and biological stages and for this reason most of the values of organic and inorganic indicators are high. The WWQI classification under the World Health Organization is more accurate and realistic in terms of the effluent quality receiving sources.

Table 7 WWQI classification during 2012-2016.

Year	Iraqi standard (IQS)		WHO standard	
	Overall WQI	Class	Overall WQI	Class
2012	90.01	Good	289.06	Very Poor
2013	124.51	Poor	377.42	Polluted
2014	67.34	Good	229.52	Very Poor
2015	258.59	Very Poor	811.02	Very Polluted
2016	299.38	Very Poor	952.66	Very Polluted
Average	167.97	Poor	531.94	Very Polluted

Continuous population growth with increased challenges on water resources, have been encouraging wastewater reuse in an attempt to reduce the pressure on the environment by providing additional water resources. The reuse of treated wastewater effluents is increasingly adopted in irrigation and landscape irrigation if meeting with limitations of irrigation wastewater reuse [7]. As a recommendation, both training of technical staff and advanced treatment in this plant is essential to upgrade the effluent quality to achieve the required water standards.

5. CONCLUSIONS

Continuous assessment of the sewage treatment plant increases the removal efficiency due to continuous monitoring and evaluation of the technical staff and following up the accuracy of the maintenance program and the expected failures with electromechanical equipment, the utilization of the treated effluent as an alternative source for different reuse such as for irrigation purposes and reduces the pollution load on receiving surface water. In this study Al-Diwaniyah STP was investigated by considering the characteristic of its effluent during the period 2012 to 2016. The results showed that the effluent concentrations of TSS, COD, and BOD₅ exceeded the values Iraqi effluent standards which may be due to operational problems in the plant. The overall removal efficiency was low, 62.2%, 68.33%, 62.72% and 53.23% for TSS, COD, BOD₅ and NO₃ respectively. The WWQI values indicated that treated effluents fall within the category of poor-very poor according to Iraqi effluent standards and very poor to very polluted quality according to WHO standards. In general, the results indicate incomplete treatment of wastewater at the primary and secondary stages in Al-Diwaniyah STP. As a recommendation, advanced treatment in this plant is essential to upgrade the effluent quality to achieve the required water standards. In Iraq, most wastewater treatment plants do not operate under the design due to the high cost of equipment maintenance fees and lack of trained human resources

REFERENCES

- [1] Abbasi, S.A., 2002. Water quality indices, state of the art report, National Institute of Hydrology, Scientific contribution no. INCOH/SAR-25/2002, Roorkee, INCOH : 73.
- [2] Ahmad I. Khwakaram, Salih N. Majid and Nzar Y. Hama, 2012. Determination of water quality index (WQI) for Qalyasan stream in Sulaimani City/ Kurdistan Region of Iraq. International Journal of Plant, Animal and Environmental Sciences, Vol. 2, Issue 4, 148-157.
- [3] Alsaqqar, A. S., Hashim A.; and Ali M. A., 2015. Water Quality Index Assessment using GIS Case study: Tigris River in Baghdad City. International Journal of Current Engineering and Technology, E-ISSN 2277 – 4106, P-ISSN 2347-5161.

- [4] Alsaqqar, A. S., Khudair, B. H., AL-Sulaimen, A. M., 2017. Performance evaluation of the organic matter removal efficiency in wastewater treatment plants; case study Al-Diwaniyah WWTP in Iraq. *International Journal of Science and Research (IJSR)*, Volume 6 Issue 2, PP. 334-338.
- [5] Alsaqqar, A. S., Khudair, B. H., Hasan, A. A., 2013. Application of water quality index and water suitability for drinking of the Euphrates river within Al-Anbar province, Iraq. *Journal of Engineering*, Vol.19, No. 12., pp. 1619-1633.
- [6] Al-Sulaiman A.M. and Khudair, B. H. 2018. Correlation between BOD₅ and COD for Al-Diwaniyah wastewater treatment plants to obtain the biodegradability indices. *Pak. J. Biotechnol.* Vol. 15 (2) 423-427.
- [7] Bradley, B.R., Daigger, G.T., Rubin, R. and Tchobanoglous, G., 2001. Evaluation of onsite wastewater treatment technologies using sustainable development criteria. *J. of Clean Technol. and Envt.* 4, 87-99.
- [8] Debels P., Figueroa R., Urrutia R., Barra R. and Niell X., 2005. Evaluation of water quality in the Chilla'n river (Central Chile) using physicochemical parameters and a modified water quality index, *Environ. Monit. Assess.*,110(1-3), 301–322.
- [9] Eckenfelder, W., 1989. *Industrial Water Pollution Control*. McGraw-Hill Company, New York.
- [10] Gallego, A., Hospido, A., Moreira, MT., and Feijoo, G., 2008. Environmental performance of wastewater treatment plants for small populations. *Resources, Conservation and Recycling*, 52 (6), 931–940
- [11] Gijzen, H.J., 2001. Aerobes, anaerobes and phototrophs: a winning team for wastewater management. *Water Sci. and Technol.* 44(8), 123-132.
- [12] Metcalf and Eddy Inc., 2003. *Wastewater Engineering - Treatment, Disposal and Reuse*. 4th Edition, Tata McGraw Hill Publishing Co. Ltd.,
- [13] Mudiya B. N., 2012. Development of wastewater quality index for disposal in to environmental. sink – Inland Surface Waters, *Int. Conf. Emerg. Front. Technol. Rural Area*, 1-4.
- [14] Palmer, S.J., 2004. *Process Description*. Bechtel International Systems Inc. Project. no.24910-602
- [15] Raut, SB., Anaokar, GS., and Dharnaik, AS., 2017. Determination of Wastewater Quality Index of Municipal Wastewater Treatment Plant using Fuzzy Rule Base. *European Journal of Advances in Engineering and Technology*, 4(10): 733-738.
- [16] Syed R. Qasim, 1999. *Wastewater treatment plants planning, design, and operation*. CRC press, second edition.
- [17] Thrikawala, S., Gunaratne, L.H.P. and Gunawardane, E.R.N., 2008. Impact of different tariff structures on residential water demand: A case study from Kandy, Sri Lanka, *Tropical Agric. Res.* 20, 60-72.
- [18] Tyagi S., Sharma B., Singh P.; and Dobhal R., 2013. Water Quality Assessment in Terms of Water Quality Index, *American Journal of Water Resources*, 2013, Vol. 1, No. 3, 34-38.

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Quality Index

- [19] Verlicchi P., Masotti L. and Galletti A., 2010. Wastewater polishing index: A tool for a rapid quality assessment of reclaimed wastewater, *Environ. Monit. Assess.*,173(1), 267–277.
- [20] Vijayan, G., Saravanane, R., and Sundararajan, T., 2016. Wastewater Quality Index-A Tool for Categorization of the Wastewater and Its Influence on the Performance of Sequencing Batch Reactor, *International Journal of Environmental Engineering and Management*, 2016, 7(1), 69–88].
- [21] Kadhim Naief Kadhim (Estimating of Consumptive Use of Water in Babylon Governorate-Iraq by Using Different Methods). (*IJCIET*), Volume 9, Issue 2, (Feb 2018)