Waste Technology (WasTech)
Journal homepage: http://ejournal.undip.ac.id/index.php/wastech
An International Journal

Evaluation of Wastewater Treatment Plant Operating Extended Aeration and Nutrients Removal

Hiba Mohammad

Department of Environmental Engineering, Faculty of Civil Engineering, Tishreen University, Lattakia, Syria.
E-mail: hibamohammad2015@gmail.com

Abstract - *Construction of Rwaymiah Waste Water Treatment Plant, (WWTP) in city of Lattakia, Syria since 2011 but until recently it still lacks a continuous evaluation of the performance. WWTP performance evaluation is needed to see how far the efficiency of processing result. This research aims to assess the treatment efficiency and the quality of the final effluent in accordance with the required design standards for Rwaymiah wastewater treatment plant in Lattakia city, working in extended aeration combined with biological nutrients removal (BNR) technology. Laboratory analyzes and measurements periodically for period of the month of January 2013 until the end of January of the year 2016 were conducted for the indicators: biochemical oxygen demand (BOD), total suspended solids (TSS), nitrate (NO^{3-}), phosphate ($PO4^{-3}$).The results showed that the efficiency of the treatment was good to treat BOD_5 and TSS at Rwaymiah WWTP and the final effluent achieved all the required design criteria, average in plant. However, the final effluent did not achieve all the required design criteria of NO^3 and $PO4^{-3}$. In this research, we recommend to the need for periodic measurements at each plant for pollution indicators in order to monitor and adjust the efficiency of treatment facilities.*

Keywords – *WWTP performance, efficiency removal, BOD, TSS, NO^{3-}.$PO4^{-3}$.*

Submission: November 17, 2018 Correction: January 5, 2019 Accepted: February 3, 2019

Doi: http://dx.doi.org/10.12777/wastech.7.1.19-26

[How to cite this article: Mohammad, H.. (2019). Evaluation of Wastewater Treatment Plant Operating Extended Aeration and Nutrients Removal. *Waste Technology, 7*(1), 19-26. doi: http://dx.doi.org/10.12777/wastech.7.1.19-26]

1. Introduction

Increasing demand for high degree of treatment as well as existence of highly resistant organics in wastewaters such as micro pollutants has caused wider and ever increasing use of chemical treatment processes (Tünay, 2004). The objective of the installation and operation of wastewater treatment systems is to assure an environmentally friendly effluent quality meeting the determined border values (Wendland, 2005).

In the last 20 years a special interest has risen to implement wastewater treatment plants (WWTPs) in Lattakia City, Syria. There are important efforts made for improving water management, with main focus on distribution system, storage and sanitation. (Ministry of Health, 2000). There are six WWTPs in Lattakia City, but none is functioning effectively (Kassem et al, 2011; Saied et al. (a), 2014).All working WWTPs in Lattakia faces challenges of operation, maintenance and the most important is the absence of sludge removal in addition to high energy consumption (Mohammad et al (a), 2015 and Abd Alkader et al, 2013).They are not sophisticated treatment technology, its consist of extended aeration. Rwaymiah WWTP is the only treatment plant which has nutrients removal (MPWH, 2013).The use of the extended aeration system exceeded 98% of wastewater treatment technologies considered in Lattakia neglecting all other possibilities (JICA, 2007). WWTP performance evaluation is needed to see how far the efficiency of processing is generated. Outlet quality data is compared to the specific standard (No. 2752) of 2008for treated wastewater used for irrigation.

According to JICA (2007), the actual values of BOD_5, TSS, NO_3, and PO_4 are (310; 360; 74 and 24) mg/l, respectively. While the design values used for WWTPs design are 400 mg/l and 460 mg/l of BOD_5 and TSS respectively. Turkmany (2009) argued that there is no holistic study had been conducted in the past aboutBOD_5, phosphorous, ammonia and nitrates loads. He considered extended aeration as not a developed method to be used constantly.

Saied et al. (2014, b) summarized the problems facing wastewater treatment plants in Lattakia as follows: the large discrepancy between the values of actual and design parameters of the treatment plants, the enormous consumption of electric power caused by design errors and poor management of the technological process in wastewater treatment plants and the weakness of governmental expenditure and the maintenance strategy which negatively affects the efficiency of operation and investment of the treatment plants. While Kaisiet al (2005) highlighted lacking of trained staff for monitoring the closed circuits in the wastewater treatment plants. In addition to the lacking of specialized technical staff for the management, operation and maintenance of treatment plants, and for monitoring and analysis of solid, liquid and gas wastes.

The objective of this study is to evaluate the treatment system performance in respect to biochemical oxygen demand (BOD), total suspended solids (TSS), nitrate (NO^{3-}), phosphate ($PO4^{-3}$) parameters.

2. Materials and Methods

Rwaymiah WWTP is located to the east of Lattakia, Syria. The plant treats wastewater drained from Rwaymiah town. It uses extended aeration method with biological nutrient removal (BNR). The process considered is a small-size treatment plant, which designed for 7702 population equivalents.Table (1) gives the raw wastewater and treated wastewater characteristics for the design year of 2030.

Table 1. Theoretical design data for Rwaymiah WWTP

Parameter	Inlet	Outlet
pH	7-9	7.5-9
BOD_5 (mg/l)	586	20
TSS (mg/l)	660	30
PO_4 (mg/l)	25	3
TN (mg/l)	100	20
Design Parameters		
Hydraulic Retention Time (HRT, hour)		24- 36
Volumetric loading rate($V_{L.d}$, Kg/m^3)		0.16- 0.4
F/M Ratio (Kg BOD/Kg MLSS. d)		0.05- 0.15

The plant consists of influent pumping, mechanical screening, aerated sand and grit chamber, A^2O activated sludge process, sedimentation tank in the center of the aeration tank, chlorine disinfection, and solids handling processes.Treated effluent from the plant discharges to a nearby stream. Sludge is thickened and dewatered on-site. Oxygen for the aeration tank is supplied by two operated blowers and a system of stationary diffusers. Figure 1 shows the scheme of the Rwaymiah WWTP.

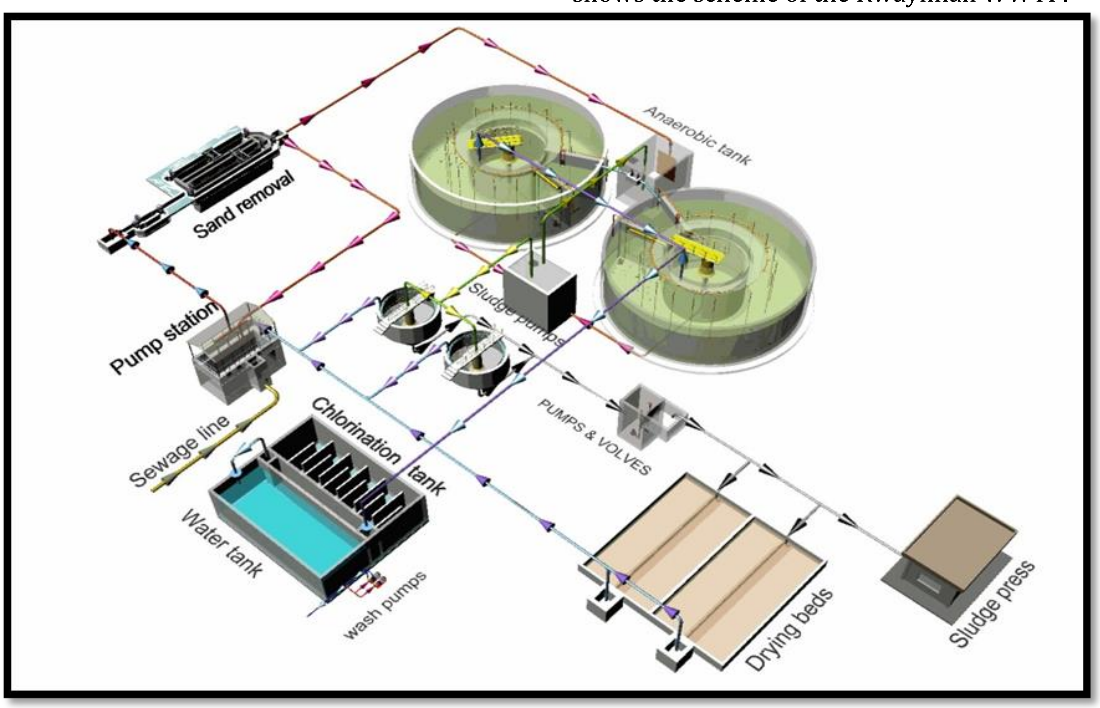

Figure 1. Process flow diagram of Rwaymiah WWTP

The plant has the designed capacity of 1039 m3/day and the designed operating time is 16 hours a day. The average actual flow of wastewater during the study period is found to be 360 m3/day due to 3 hours operation time of the pump station at the inlet . The number of persons connected to Rwaymiah WWTP amounted to 5722 actual persons during the study period.

WWTP performance evaluation activities as in the chart below (Figure 2).

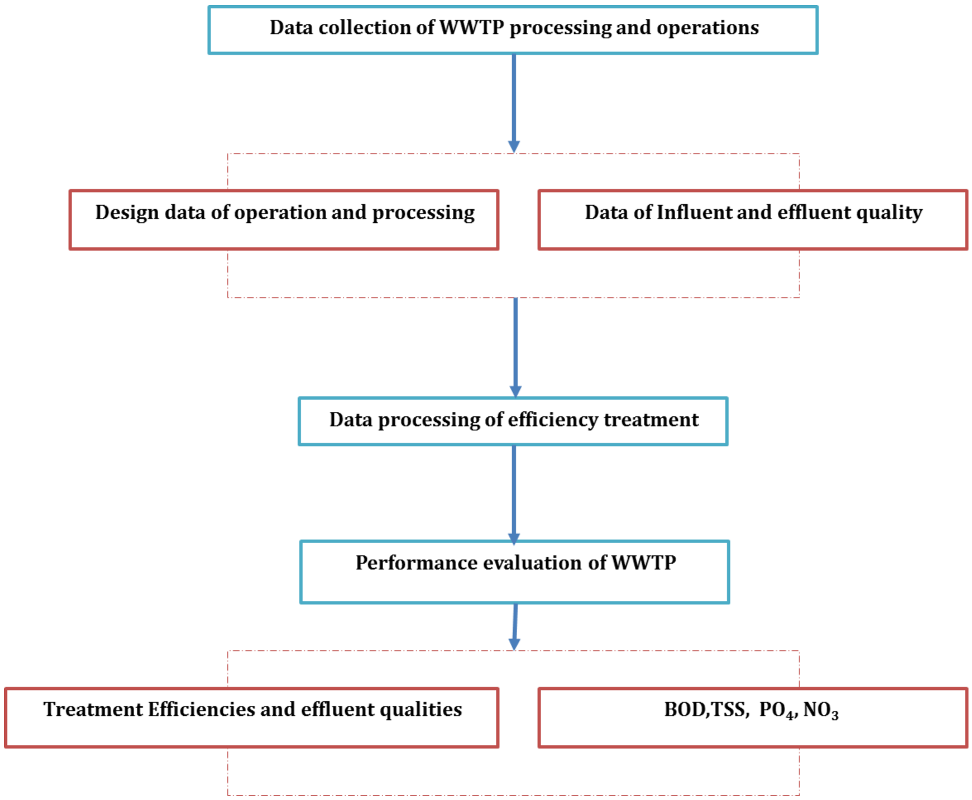

Figure 2. Flow diagram of WWTP performance evaluation

The activities which were done to accomplish the performance evaluation are following:

1. Consultation with Rwaymiah WWTP operators to fulfill data collection of operations and process design data.
2. Sampling and analysis of influent and effluent quality parameters that includes the concentration of BOD_5, TSS, TDS, PO_4, NO_3. Analysis some impact factors on the energy consumption.
3. Analysis of the quality of wastewater samples carried out according to the following methods according to (APHA, 1995).
4. Processing of the data to gain treatment efficiencies.
5. Evaluation of the performance from treatment efficiency, BOD_5, TSS, PO_4, NO_3.

The observed results of effluent concentrations and removal efficiencies of the constituents BOD, TSS, PO_4 and NO_3 are compared with the typical expected performance reported in the literature. Table 2 shows the typical mean influent, effluent concentrations and removal efficiencies, according to the literature review (Syrian Arab Standards and Metrology Organization (SASMO) NO. 2752, 2008).

Table 2. Typical mean effluent concentrations and removal efficiencies

No.	Parameter	Unit	Effluent	Removal efficiency (%)
1	BOD_5	mg/l	30	95
2	TSS	mg/l	50	93
3	PO_4	mg/l	20	88
4	NO_3	mg/l	60	95

The General overview of sampling is as follows in Table 3.

Table 3. Overview of Sampling

No.	parameter	Operation period	Number of samples
1	BOD_5	Jan.2013 –Jan.2017	162
2	TSS	Jan.2013 –Jan.2017	187
3	PO_4	Jan.2013 –Jan.2017	172
4	NO_3	Jan.2013 –Jan.2017	149

3. Results and Discussion

The results of the average, minimum and maximum influent and effluent concentrations of water quality parametersBOD_5, TSS, PO_4 and NO_3during the study period can be seen in figures(3, 4, 5, 6), respectively.

Figure (3) illustrates the average, maximum and minimum values of BOD_5 concentrations in the monitored influent and effluent of Rwaymiah WWTP. The average influent BOD5 concentration was (113 mg/l), while the average effluent BOD5 concentration was (27 mg/l). The maximum influent BOD_5 concentration was (205 mg/l), while the maximum effluent BOD5 concentration was (94 mg/l). The minimum influent BOD_5 concentration was (21 mg/l), while the average effluent BOD_5 concentration was (9 mg/l).

Figure (3) shows that on average the influent value is (81%) less than the design value (586 mg/l), and the maximum and minimum values are (65% and 96.4%) less than design value. The minimum influent value (21 mg/l) seems unacceptable because it will definitely affects the whole operation process negatively. It seems that the original design of the unit operations of Rwaymiah was not based on real data of wastewater analysis but assumed values. Possible explanations that could justify the very low concentrations of BOD_5 might be: the behavior of household's inhabitants, types and amount of detergent used by households, food style and meals patterns, or low per capita water consumption.

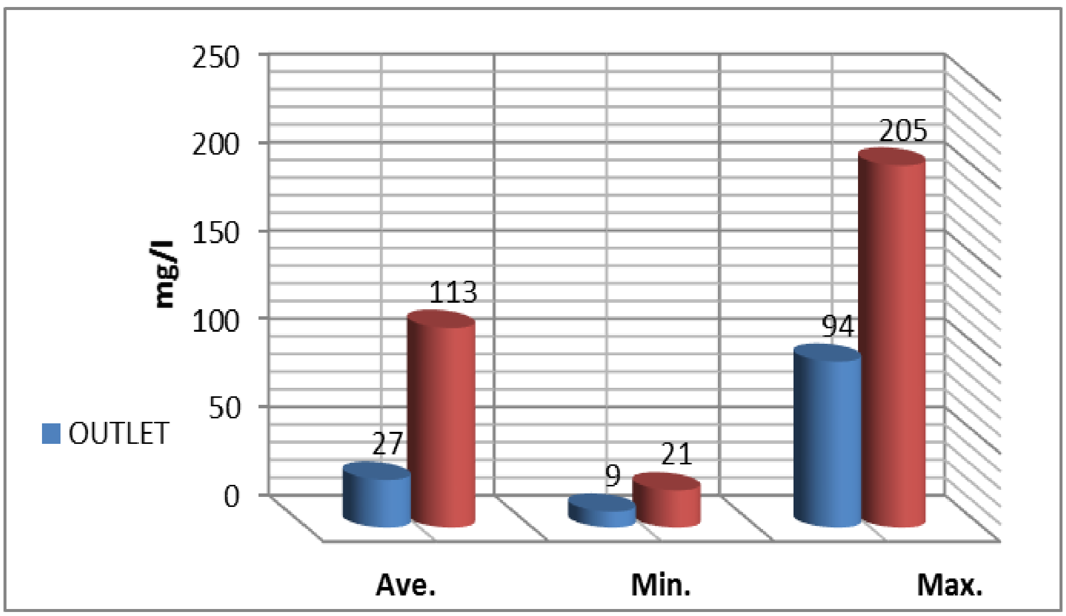

Figure 3. BOD_5 concentrations

The concentration of BOD_5 in the effluents decreased compared to the average concentration of BOD_5 in the influents. The average effluent BOD_5 was (27 mg/l). The lowest BOD_5 concentrations being in the influent was (9mg/l). On the other hand, the quality of effluentBOD_5 (27 mg/l) is generally above the standard (20mg/l). While the maximum value of effluentBOD_5 is (94 mg/l) which refers to poor performance. Average and maximum BOD_5 concentrations were observed to be higher than (20mg/l) in the effluents of Rwaymiah WWTP. The lowest BOD_5 appeared at the influent, the reason of that may explained due to occurred malfunction in submersible pumps which preventing and hardly transferred the flow of wastewater from septic tank stage.

On Average effluent quality meets the requirements of treated water used in irrigation (30mg/l), but we must look an open eye to the exceedingly increase in maximum (94 mg/l) of BOD_5 which cause insufficient quality for irrigation as stated by (SASMO) NO. 2752, 2008), and that may effect on the characteristics of crops that are irrigated.

Figure 4 presents the values of influent to effluent TSS concentrations as average, minimum and maximum. It shows that influent TSS values are (112 mg/l; 42mg/l; 173 mg/l) as average, minimum and maximum levels, respectively. The Influent TSS is generally (83%) lower than the design value (660 mg/l), while the maximum value reported during the study period was (73.78%) less than the design value. The minimum value reported was less than the design value by (93.63%).

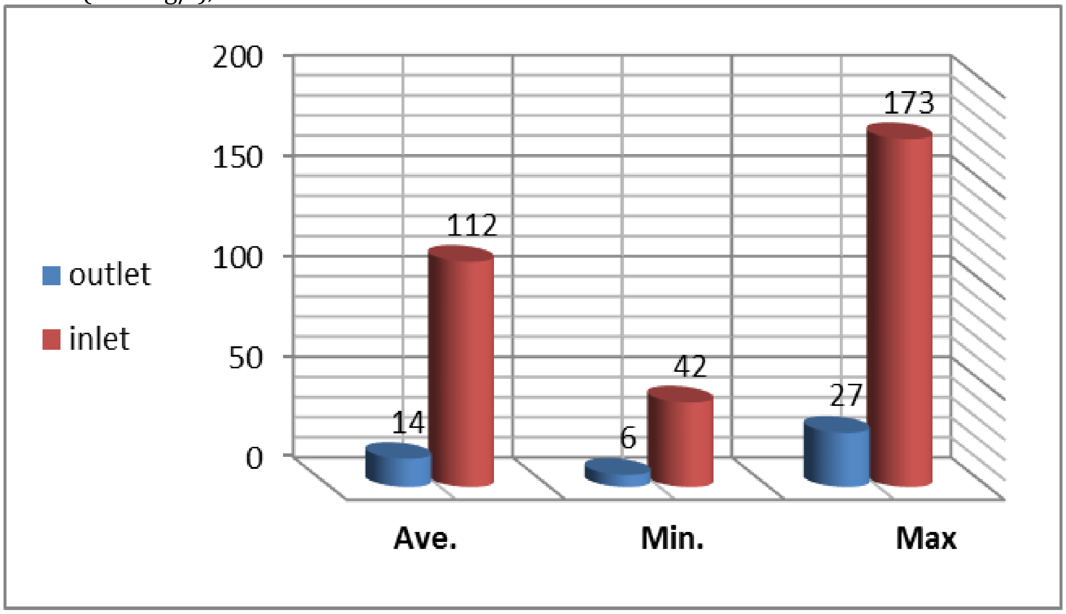

Figure 4. TSS concentrations

The average, minimum and maximum TSS effluent values were (14; 6; 27 mg/l), respectively. TSS effluent values remain under the design value (30 mg/l). The average, minimum and maximum TSS effluent values are below the design values by (53.3%; 80% and 10%), respectively. In all cases the values of effluent TSS decreased with respect to the values observed in the influent. The high TSS effluent concentrations may be due to insufficient treatment conditions.

Effluent quality is suitable for irrigation in terms of TSS concentration. Hence the TSS requirements is (50 mg/l) in accordance with (SASMO) NO. 2752, 2008) and the actual minimum, average and maximum concentrations are (6; 14 and 27) mg/l, respectively.

Figure (5) illustrates the average, maximum and minimum values of PO_4 concentrations in the monitored influent and effluent of Rwaymiah WWTP. The influent PO_4 concentrations are reported as (8.63; 3.23 and 14.66) mg/l as average, minimum and maximum values. The PO_4 value considered during the design is (25mg/l). The PO_4 influent values were below the design value by (65.48; 87.08 and 41 36) %.

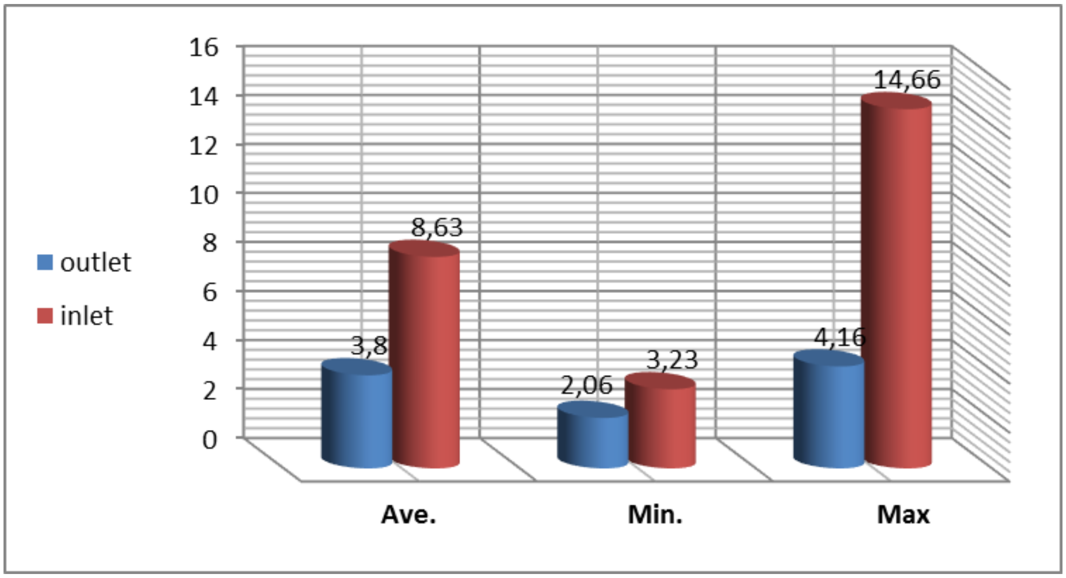

Figure 5. PO_4 concentrations

Figure (5) revealed that the effluent values were (3.8; 2.06 and 4.16 mg/l) as average, minimum and maximum levels, respectively. The PO_4 design value in the effluent is (3mg/l). The lowest PO_4 concentration in the effluent was (2.06 mg/l) less than the design value by (31%). The maximum and average PO_4 effluent concentrations showed a slight increase above the limits. In all cases, the values of effluent PO_4 decreased with respect to the values observed in the influent.

The recommended guidelines by SASMO (NO. 2752; 2008) for treated PO_4 effluent is (20 mg/l) for reuse in irrigation. Rwaymiah WWTP have average effluent PO_4 is less than (20 mg/l) which means it is acceptable for reuse in irrigation. However, the values of the influent PO_4 did not exceed the limits of SASMO (NO. 2752; 2008), so there is no purpose to remove it.

Figure (6) illustrates the average, maximum and minimum values of NO_3 concentrations in the monitored influent and effluent of Rwaymiah WWTP.

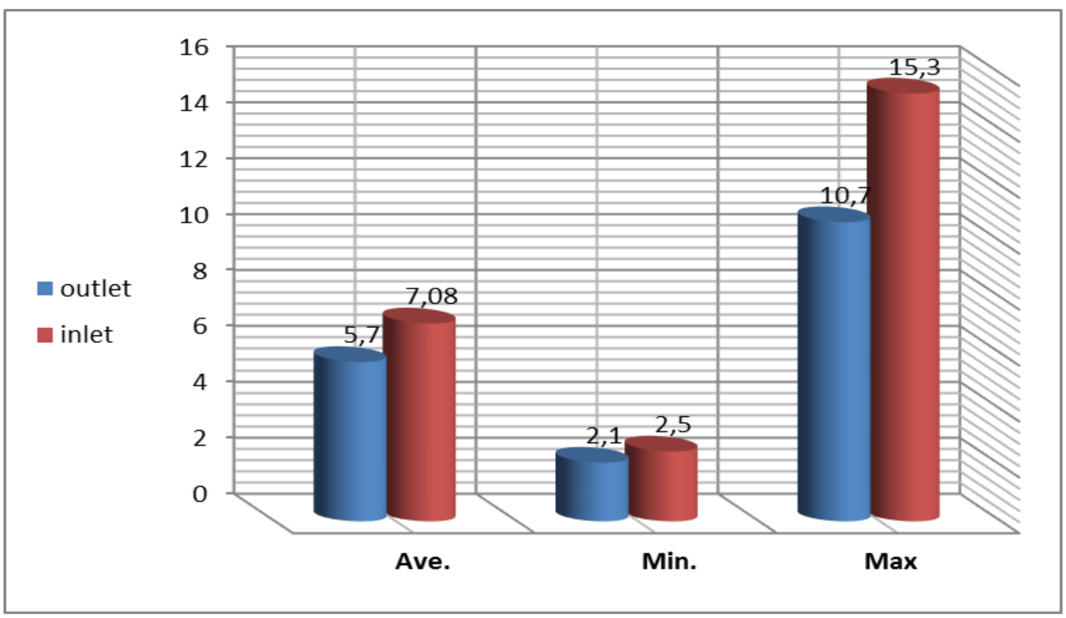

Figure 6. NO_3 concentrations

Figure (6) shows that the NO_3 concentrations in the influent remain below the design value (100 mg/l). It varies in rang of (2.5 mg/l) in minimum, (7.08 mg/l) in average and (15.3 mg/l) in maximum. Moreover, It is below the design value by (97.5%; 92.92% and 84.7%), respectively. It should be noted that the observed low NO_3 influent concentrations in terms of design was not expected, although this WWTP was designed to remove nutrients. Furthermore It also revealed that there was large variation in the influent NO_3 which ranged from (2.1 mg/l) as minimum to (10.7 mg/l) as maximum with average value of (5.7 mg/l). NO_3 effluent concentrations were below the design value (25 mg/l) by (91.6%; 57.2% and 77.2%).

According to SASMO (NO. 2752; 2003) that NO_3 concentration must not exceed 60 mg/l in order to reuse treated wastewater for irrigational purposes. So, effluent from Rwaymiah WWTP could be used for irrigational purposes to enrich the soil.

Figure (7) illustrates the average efficiency values of evaluated values. The actual average BOD_5 removal efficiency (%) is (76%). The efficiency of BOD_5 removal was less than the design value by (20%). The actual efficiency of TSS removal was 87.5%, which is less than the design value by 6%. Rwaymiah WWTP had good performance compared with the reference reported in the literature (Table 3), considering both average $BOD_5$and TSS removal efficiencies. The removal value of PO4 is (44.4%), while the design removal efficiency of PO_4 is (88%). According to this reference values of removal efficiency, Rwaymiah WWTP is performing below the expected by (49.5%). Rwaymiah WWTP had a lower efficiency compared with NO_3 removal efficiency reference reported as (95%). The average NO_3 removal efficiency (19.5%) is less than the reference value by (79%).

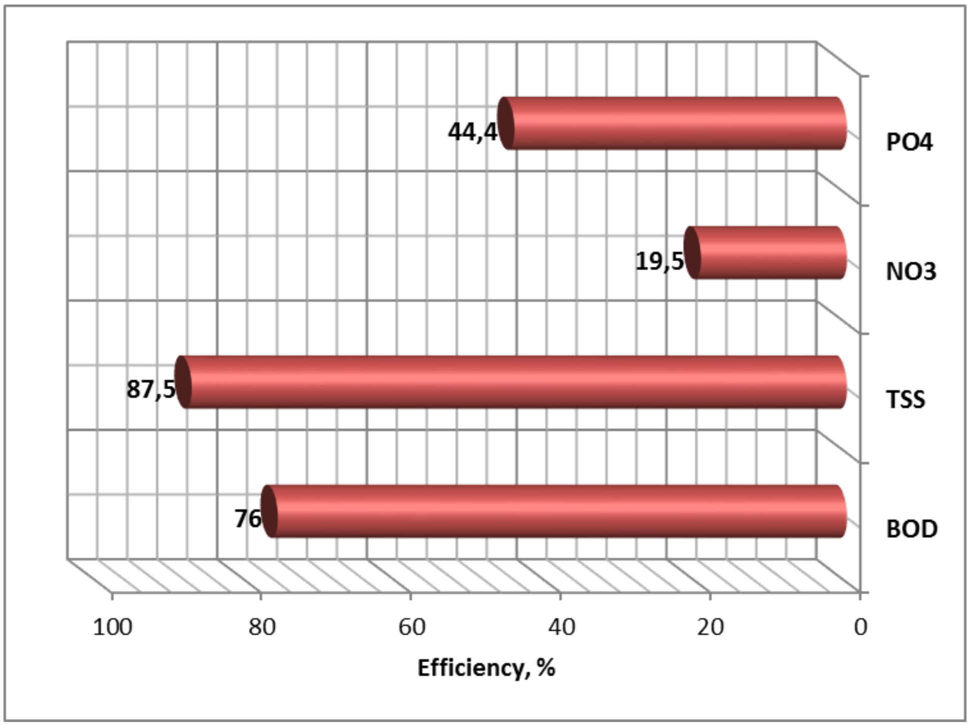

Figure 7. Removal efficiency (%)

Rwaymiah WWTP showed good BOD_5 and TSS removal efficiencies. The results of this evaluation show that low influent concentration cause biomass limited to degrade organic matter and resulting organic matter removal levels that is low (Satoh, 2007 and Hendriarianti et al., 2016). It also had a lower performance compared with the PO_4 and NO_3removal efficiencies reference range reported in the literature. However, considering average PO_4 and NO_3 effluent concentrations values were closer to the reference in all cases. However, considering PO_4 and NO_3 removal efficiencies, the performance was below the expected. Also here as mentioned above the observed low PO_4 and NO_3 removal efficiencies were unexpected, where Rwaymiah WWTP has been designed for nutrients removal.

However, considering all removal efficiencies, the performance of Rwaymiah WWTP was below compared with the reference ranges reported in the literature.

4. Conclusions

Rwaymiah WWTP showed good BOD_5 and TSS removal efficiencies, but a lower performance compared with the PO_4 and NO_3removal efficiencies reference range reported in the literature. However, considering average PO_4 and NO_3 effluent concentrations values were closer to the reference in all cases. We have to keep an open eye that considering PO_4 and NO_3 removal efficiencies, the performance was below the expected. Also here as mentioned above the observed low PO_4 and NO_3 removal efficiencies were unexpected, where Rwaymiah WWTP has been designed for nutrients removal. However, considering all removal efficiencies, the performance of Rwaymiah WWTP was below compared with the reference ranges reported in the literature.

Another point is that the original design of the unit operations of Rwaymiah WWTP was not based on real data of the quantity and analysis of wastewater but assumed values. The variability of performance for Rwaymiah WWTP is mainly influenced by temporary changes of the raw loads, the elimination rate, and the current situation for each. The availability of experienced engineering designer, skilled personnel, spare parts for repair, and effective operation, maintenance and monitoring are more crucial than the type of technology.

Although Rwaymiah WWTP was designed for nutrients removal, but after the analytical analysis for laboratory results we noticed that nutrients concentration in the influent are much less the design values. According to SASMO (NO. 2752; 2003), effluent from Rwaymiah WWTP could be used for irrigational purposes to enrich the soil.

It recommends to take clear measurements in order to reduce the problem of wasting money used for capital, operational and maintenance expenditures and it has to be a clear strategy for management. It must be monitor and maintenance in order to make sure of its effectiveness

Acknowledgement

Special thanks to Rwaymiah WWT Poperators for technical assistance so we can complete this research.

References

[1] AbdAlkader M., Sabboh H., Jafar R. 2013. Modelling and Simulation of Wastewater Treatment Plant in Small Agglomeration in The Coastal Zone. Tishreen University Journal for Research and Scientific Studies - Engineering Sciences Series: 35(9), pp. 249- 268.

[2] APHA. 1995. "Standard Methods for the Examination of Water and Wastewater", 18th ed. American Public Health Association.

[3] Hendriarianti, E., &Karnaningroem, N. (2016). Evaluation of Communal Wastewater Treatment Plant Operating Anaerobic Baffled Reactor and Biofilter, 4(April), 7–12.

[4] JICA. 2007. A study on the development of the sewage system in the Syrian Arab Republic. Syria. Pp35.

[5] Kassem, S., Dbaliz, A., Jnad, H. 2011. Determine design parameters of oxidation ditch for wastewater treatment in small communities in the Syrian coastal.Master thesis, University of Tishreen, Lattakia, Syria.

[6] Kaisi A., Yasser M., Mahrouseh Y. 2005. Syrian Arab Republic country report. In : Hamdy A. (ed.), El Gamal F. (ed.), Lamaddalen a N. (ed.), Bogliotti C. (ed.), Guellou bi R. (ed.). Non-conventional water use:WASAMED project. Bari : CIHEAM / EU DG Research . p. 2 51 -2 64 (Option s Méditerranéen n es : Série B. Etu des et Recherches; n . 53)

[7] Ministry of Health. 2000. Health Villages Project. The implementation of Healthy Villages Projects in Syria. pp. 1-22. Damascus, Syria.

[8] Mohammad H.; Jnad H. and Dbaliz A.(a). 2015. A contribution to energy consumption at WWTPs in Lattakia, Syria. Master thesis, University of Tishreen, Lattakia, Syria.

[9] MPWH (Ministry of Public Work and Housing). 2013. Public Company for Sewage in the province of Lattakia: Company Profile and achievements. pp. 1-58. Lattakia, Syria.

[10] Saied, M., Awad, A., Sabbouh, H.(a). 2014. Efficiency Evaluation of Some Wastewater Treatment Plants in Lattakia City. Tishreen University Journal for Research and Scientific Studies - Engineering Sciences Series, 36(6) :431-446.

[11] Saied, M., Awad, A., Sabbouh, H.(b). 2014. Efficiency Evaluation of Some Wastewater Treatment Plants in Lattakia City. Master thesis, University of Tishreen, Lattakia, Syria.

[12] Satoh, H. M. 2007. Layered Structured of Bacterial and Archaeal Community and their in situ activity in anaerobic granules. Applied Environment Microbiology 73, 7300-7307.

[13] Syrian Arab Standards and Metrology Organization (SASMO). 2008. Syrian Standard No. (2752) for treated wastewater for irrigation use - (First revision).

[14] Tünay,O. 2004. Developments in the application of chemical technologies to wastewater treatment. Water Science & Technology: 48(11), 43–52.

[15] Turkmany, A. 2009. National plan for wastewater management in Syria. PP 55. Available at: http://www.4enveng.com

[16] Wendland,A.2005.Operation costs of wastewater treatment plants. Ahrensburg.Germany.EMWATER E-learning course. Pp1-24