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Determination of design parameters of urban wastewater treatment plants in the cold regions of Iran

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ABSTRACT

Aims: This study has been conducted to focus on the localization of the design parameters used for the design of wastewater treatment plants in a region of Iran.

Materials and Methods: Three wastewater treatment plants were selected (as models) in a cold weather region of Iran. The main characteristics of the wastewater, such as, flow rate and its fluctuations, total solids, and the organic and nutrient contents, which play an important role in the design and operation of the wastewater treatment facilities, were measured for the selected plants during a year.

Results: The averages of the design parameters for the investigated plants, including, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), volatile suspended solids (VSS), total Kjeldahl nitrogen (TKN), and total phosphorous (TP) were, 41, 60, 65, 47, 8.3, and 0.93 g/capita, respectively. Wastewater production was 177 lit/cap-day with a maximum and minimum coefficient of 1.76 and 0.29, respectively.

Conclusions: Using design parameters based on the local characteristics and the real-world conditions of the wastewater, can result in more+operational efficiency in the wastewater plants. It is suggested that the results of this study can be applied to the design of wastewater facilities throughout Iran, with the same local conditions.

Key words: Design parameters, Iran, organic loading, urban wastewater

INTRODUCTION

Wastewater collection and treatment facilities are needed for human communities to meet the requirements of public health and environmental sanitation. With the future needs and the development of cities, it is estimated that the construction of 800 urban wastewater treatment plants is needed in Iran until 2011.[1] For such an investment, the design of the facilities must be based on the parameters compatible with the local conditions and the wastewater characteristics.

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Previous experiments have shown that lack of attention to these principles cause many problems in the operation of the facilities. The capacity of the wastewater treatment units (especially the biological processes) is impressed by organic loading and daily flow of the wastewater. Thus, we need some important parameters such as capital amounts of; BOD_5, COD, TSS, VSS, TKN, Total Phosphorus, and also an inlet flow to the facilities, and the temperature and pH of the wastewater to be treated. In Iran, wastewater treatment plant designs have already been accomplished based on the coefficients applied in other countries, which in many cases are not compatible with the conditions in Iran and cause excess cost, wrong design, and operational problems (for example, over design or under design problems).[2] However, these parameters can be used to upgrade the old facilities.[3]

The objective of this study is to determine the design principles of the wastewater removal facilities with a potential

for the development of design and operation, based on the condition of the local criteria. The study will also focus on the development of the skills of local designers and knowledge improvement of the taskmasters, with regard to the correct performance of urban wastewater projects in the local conditions of Iran.

MATERIALS AND METHODS

This was an experimental study. The chemicals used in this study for measuring the wastewater characteristics were of reagent grade and purchased from MERCK Co. For pH measurement, a Drion pH electrode pH/T°c model 520 A was used. The pH probe was checked for true readings before running any test. BOD_5, TKN, TP, TSS, and VSS were measured according to the procedures stipulated in the Standard Methods–twentieth edition.[3] The chemical oxygen demand (COD) was followed according to the Dichromate Reactor Digestion made by the HACH's COD method, using a COD reactor (HACH Co. Hach Method 8000) with reagents for low COD.[4]

The type of sampling selected, except for pH and T°c, was the flow-proportioned sampling method.[5] All measurements for the experimental analysis were done in triplicate. The flow rate was expressed as m^3/d and measured for 365 days. Also, BOD_5, COD, TSS, and VSS were expressed as milligram per liter and measured for 122 samples, and TP and TKN were expressed as mg/l, for 73 samples. For measuring the temperature and pH, every six hours one sample was taken and expressed as a daily average.[6] This research was based on empirical studies that had been conducted to indicate the basis for the design of wastewater treatment plants in a region of Iran. Thus, three wastewater treatment plants from the cold climate of the Chaharmahal and Bakhtiari province, Shahrekord, Farsan, and Brojen [Table 1], were selected [Figure 1]. During the study we measured the parameters affecting the design and operation of wastewater removal facilities. Then, the results were compared with the same principles used in the project design by consultant engineers and also with applied design parameters from other countries as well.

RESULTS

The principles used by the consulting engineers and the groups studying designing under the study facilities are given in Table 2. The average concentration characteristics of daily inlet wastewater are given in Table 3. Results of the calculation of capital flow and pollutants on each day are given in Table 4.

The study shows that the difference between pollutant production rate (BOD_5 and COD) per capita, per day, in these regions in Iran, is significant, when compared with those in other countries [Table 5].[7,8]

In this study the COD/VSS ratio was 1.30, which was less than that in the other regions. These results showed that the wastewater in different regions varied in biodegradability characteristics [Table 6].

The ratio of Kjeldahl-N/COD in the study plants was more than that in other research locations due to less COD [Table 5].

DISCUSSION

The results showed the amounts assumed by the studying groups in the design step of the plants were different from the real amounts in the operation step. The results showed that the daily averages of BOD_5, COD, TSS, VSS, N-Kjeldahl, and TP were 231, 339, 371, 269, 47, 5.2 mg/l, respectively. The ratio of minimum to average daily flow (minimum coefficient) and the ratio of maximum to average daily flow (maximum coefficient) were 0.29 and 1.76, respectively. The hydraulic and organic loading rates were important parameters controlling the capacity design of the facility's wastewater treatment plant. The wastewater flow and organic loading rate in developed countries were 410 l/d and 95 g/day-cap, respectively.[9,10] This was almost two-fold when compared with those in Iran. As the wastewater characteristics were usually affected by the local conditions, such as, the social, economical, and cultural native attitudes, the design parameters of urban wastewater facilities had to be localized, to optimize the project's efficiency. In addition to

Table 1: General design and operation characteristics of WWTPs

Plant name	Process type	Population	Operational flow) m^3/d)	Design flow (m^3/d)
Shahrekord	Activated sludge	152596	28907	54270
Brojen	Activated sludge	53629	9159	33000
Farsan	Activated sludge	11978	1995	3116

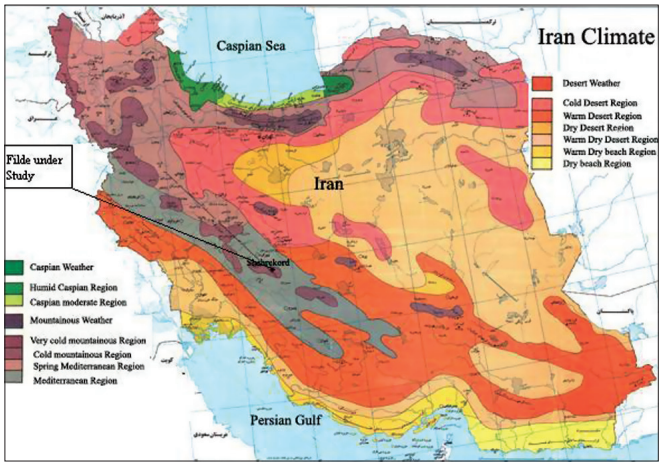

Figure 1: Study site of a region with cold weather, in Iran

Table 2: Comparison of results for design principal in three plants

$WWTP_s$	Years	Population served	SS (g/cap-d)	BOD_5 (g/cap-d)	Flow (l/cap-d)	SS (mg/l)	BOD_5 (mg/l)	Max. coefficient (K)	Max. wastewater flow (m^3/day)
Shahrekod	1996	180000	80	54	150	533	360	1.71	88920
Shahrekod	2006	260000	100	65	200	500	335	1.71	104520
Shahrekod	2007	152596	70	42	189.5	371.7	221.4	1.4	28907
Brojen	1996	116000	80	54	150	533	360	1.7	33060
Brojen	2006	170000	100	65	200	500	325	1.7	64600
Brojen	2007	53629	64.4	40.5	174.5	370	232.1	1.6	9159
Farsan	2002	24500	55	50	106	433	393	2.93	3116
Farsan	2006	35431	55	50	134	342	311	2.76	5698
Farsan	2007	11978	61.2	40.2	167	370	240	2.27	1995

Table 3: Daily average of inlet wastewater characteristics to three plants

Wastewater treatment plants	BOD_5 (mg/L)	COD (mg/L)	TSS (mg/L)	VSS (mg/L)	TKN (mg/L-N)	$P(PO4^{-3})$ (mg/l-P)	T°C
Shahrekord	221 ± 47	323 ± 10	372 ± 34	272 ± 5	45 ± 0.78	5 ± 0.2	14 ± 3
Brojen	232 ± 31	345 ± 7	370 ± 35	266 ± 5	47 ± 0.8	5.4 ± 0.14	14 ± 3
Farsan	240 ± 36	348 ± 7	370 ± 40	269 ± 4	48 ± 0.8	5.2 ± 0.2	14 ± 3

Table 4: Pollutant production per capital inlet to three plants

$WWTP_s$	Flow (l/d)	COD (g/d)	BOD_5 (g/d)	TSS (g/d)	VSS (g/d)	TKN (g/d)	$PO4^{-3}$ (g/d)
Shahrekord	189 ± 8	61 ± 3	42 ± 3	70 ± 7	51 ± 5	8.5 ± 1	0.98 ± 0.2
Brojen	176 ± 9	60 ± 5	41 ± 3	64 ± 4	46 ± 5	8 ± 0.8	0.9 ± 0.2
Farsan	167 ± 9	58 ± 4	40 ± 3	61 ± 5	44 ± 7	8 ± 0.9	0.9 ± 0.2

Table 5: Comparison of capital pollutant contents in study plants and other regions

Component	Production of pollutant per capita (g/d)				
	Study plants	Tehran	New Deihli	Pennsylvania	India
BOD_5	41	36	45 – 54	85	85
COD	60	62	72 – 103	60 – 210	-
TSS	65	52	170 – 220	65	65
TKN	8.3	10.5	6 – 12	-	-

BOD_5: Biochemical oxygen demand, COD: chemical oxygen demand, TSS: Total suspended solids, TKN: Total Kjeldahl nitrogen

Table 6: Comparison of applicable ratios of wastewater between study plants and other sites

Ratio	Study plants	Sahebgharanieh	South Africa
BOD_5/COD	0.68	0.56	0.5
TKN/COD	0.14	0.16	0.07 – 0.1
VSS/TSS	0.72	0.73	-
COD/VSS	1.3	1.67	1.45

BOD_5: Biochemical oxygen demand, COD: chemical oxygen demand, TSS: Total suspended solids, VSS: Volatile suspended solids, TKN: Total Kjeldahl nitrogen

the planning of the wastewater disposal projects, localization of the design parameters was necessary, to prevent some problems in operation and maintenance of the facilities.

The results in Table 6 show some capital parameters such as, the COD and TKN in the field study, which were less than those of the Tehran Sahebgharanieh plant, where the COD and TKN were 62 and 10.5 mg/L, respectively. The reason could be related to the cultural foundations, accessible possibilities or local conditions. Figure 2 illustrates the variations in the hourly average of the wastewater flow. Minimum hourly flow occurred at 3 – 5 a.m., and maximum

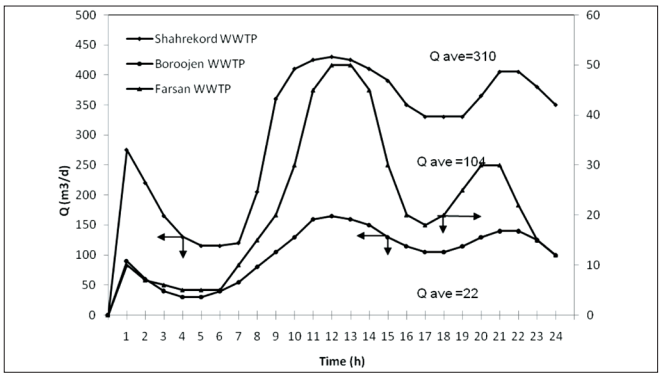

Figure 2: Variation in hourly average of influent wastewater flow to three plants

hourly flow occurred twice a day, one peak was at 11 a.m. and the other one was at 6 – 9 p.m.

The BOD/COD ratio in this study (obtained by dividing the average BOD result by the average COD result) was more than those of the Sahebgharanieh and South Africa plants. The conversion factor was 0.68. That means it was easy for it to biologically decompose. The COD/VSS ratio of 1.42 was generally accepted; Ekama *et al*. recommended 1.48 for the COD/VSS ratio, based on the actual measurement. This relationship allows an estimation of the mass balance between the daily energy entering the plant and that leaving via the activated sludge waste and effluent.[11,12]

In order to prevent some of the operational problems and excessive costs due to over design, it is clear that the wastewater treatment plant's design must be based on the

actual situations of that region. This study emphasizes on a deviation in the design parameters used by the studying team, for designing of the wastewater disposal facilities and actual amounts achieved under local conditions.

The study shows that for preventing many problems in the design, construction, startup, and operation of the facilities, the professional engineers who design wastewater disposal systems must accomplish their programs by taking into consideration the conditions where the project is to be executed.

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