Water Consumption, Domestic Wastewater Generation and its Biodegradability, Based on Monthly Income and Ambient Temperature, in Kermanshah City

Almasi Ali[1], Ayvazi Mohamad Taghi[2], Rezaei Mansoor[3], Amir Poor Ehsan[4]

[1]Kermanshah univ. of Medical Sci. (KUMS), Iran
[2] Kermanshah univ. of Medical Physic (KUMS), Iran
[3] Kermanshah univ. of Biostatistic (KUMS), Iran
[4]Water and Wastewater Company of Kermanshah, Iran

Abstract

The aim of this study is to investigate water consumption, domestic wastewater generation and organic matter concentration, based on both, socio-economic status and some meteorological parameters including temperature.

The method of this study is descriptive and analytical. A checklist was used to collect data on socio-economic status. Water consumption was obtained based on water bills. Generated wastewater and organic matter such as biochemical oxygen demand (BOD) per capita/day were measured every four hours, during a day.

Comparing water consumption in winter and summer showed significant difference in three regions. The water consumption was (398 ± 75, 291 ± 48 and 188 ± 50) for warm climate and (200 ± 25, 188 ± 35 and , 140 ± 41) in cold weather. In spite of an apparent difference in BOD in three regions, it was not significant statistically. Water consumption has strongly considerable relationship with socio- economic status (P value<0.001 and r =0.98), while the generated wastewater in these regions were not different, statistically for warm climate (220 ± 60, 204 ± 15 and170 ±34) , and in cold weather (170 ± 21, ;158 ± 31 and 112 ± 29), also the generated wastewater did not have considerable difference in cold climate.

This study confirms that, the effects of these two parameters, i.e., monthly economical income and seasonal variations on water consumption, generated wastewater and biodegradable organic loading per capita/day is considerable. It was concluded that water consumption and wastewater generations were much more in warm climate than in cold weather. Finally through this study the estimation of water consumption, wastewater generation and BOD concentration becomes possible.

Keywords: water consumption, wastewater Generation, organic load, monthly Income and Temperature.

Introduction

Rapid growth of population and widespread consumption of resources, particularly, water usage for domestic and industrial purposes; have led to generate excessive amount of wastewater. Determination of wastewater is a fundamental step for planning of the facilities such as: collection conduits, treatment processes, and disposal.

Access to a proper design, related to wastewater treatment planning without any problem, is important. This required certain knowledge concerning quality and quantity of wastewater. Domestic wastewater resulting from residential consumption of water constitutes a gray liquid (Tchobanoglous *et al*. 2003).

Increased environmental contaminants in the form of detergents, solvents, disinfectants, herbicides and pesticides, are all additive factors. These are associated with the biological environmental pollutants, such as water and soil resources (Gabriel Bitton 1999). Assessment of wastewater and characterization of its qualities is of prime importance. The selection of best method to collect, treatment and disposal of wastewater does need a full detection of both the quality and the quantity. Characterization of wastewater is the main strategy which affects wastewater management and the safeguarding goals of the environment. The design of unsuitable reservoirs not only results in failure of environmental protection goals, but in addition that would be waste of budget (Larry 1998). It is worth of mentioning that the applied involved pattern in describing revenue operation from different units should be designed and calibrated in accordance with wastewater characteristics.

The generated wastewater proportion from water consumption has some effects on pollutant concentration. Treatment efficiency in biological processes is influenced by flow and the constituents of the influent (Shaheen 2000). Measurement of wastewater variations and determination of its minimum and maximum points are essential in order to design, collected ducts, drainage canal and treatment plants. For example, it is an essential matter removal of some pollutants which exists in flow changes and concentration are essential (Henz *et al*. 2002, Dohs and Eckstädt 2003).

Murdes et al.(2005) in a study entitled "Assessing the relevance of intervening parameters on the water consumption in Brazilian Urban communities in 96 city of Brizil" considering three cardinal parameters: including accounted percentage of water, water price and consumed energy for water supply activities, they found that water price is the most influential factor on water consumption per capita in city populations.

The goals of this study relate estimation and prediction of water consumption, wastewater generation, and biodegradable substances in domestic wastewater. The relationship of the mentioned parameters with that of economical income and meteorological conditions are the complementary aims of the study.

Materials and Methods

The method of study is descriptive and analytical. The target community was considered in three are named: Kasra, Ellaheiah and Taavon. This consideration was based on the urban population size (713000) and socio-economic status. In the economical status point of view the three mentioned areas were classified as wealthy, moderate, and poor respectively. This urban classification is well recognized both formally and publicly. The population of these areas are as follows: Kasra 24440; Ellahieh 37537 and Taavoon 30318, which were chosen as the samples of city population. Based on a pilot study on 150 families randomly selected, each consumer's income was estimated by using an appropriate questionnaire. The wastewater outlets in these areas were selected as sampling stations for the determination of flow rate and other characteristics.

By means of water and wastewater company data the required samples were determined. In this study 36 samples were needed, that for to increase precision, 72 compound samples were collected every four hours during a day. The week days were selected randomly for a year, and these samples undergone testing. Half of these samples were prepared in average temperature of 10^{o}C and for the second half the temperature was 20 ^{o}C. Six set of these samples, each containing 300ml of wastewater were collected and kept in a fridge for further analysis physico-chemically.

By using the data on the water bill, the consumption of water annually were determined. In addition by applying the method of Parshall flume the generated wastewater was measured two days in a month randomly, throughout a year. This project was carried out in two different climates; cold and warm. The average warm and cold temperatures were considered to be 20 and 10 respectively. Considering practical restriction, every measurement was performed eight times in each region and climate. All parameters have been measured based on the Standard Methods (A.P.H.A. 1995, Tchobanoglous *et al*. 2003).

Results

The results show a significant relationship between water consumption and socio–economic status ($p<0.001$, $r^2= 0.98$), but, partial generated wastewater was not different statistically, the mean values of BOD were 62, 62.4 and 56, g/capita/day, for three regions of study named: Kasra, Ellaheiah and Taavon respectively. The step by step linear regression of the data is led to produce the following equations.

$Y_{water1}= 8.167+9.442(T)$	,($r^2=0.371$)	, ($p<0.001$)	(Eq. 1)
$Y_{water2} = -4\ 8.899 + 9.442(T) +60.03(I)$	, ($r^2=0.706$)	, ($p<0.001$)	(Eq. 2)
$Y_{water3}=118.51(I)+26.2$	, ($r^2=0.98$)	, ($p<0.001$)	(Eq. 3)
$Y_{wast1} = 107.67+4.47(T)$	, ($r^2=0.45$)	,($p<0.001$)	(Eq. 4)
$Y_{wast2} = 57.81 + 4.47(T) +22.66(I)$	,($r^2=0.71$)	,($p<0.001$)	(Eq. 5)
$Y_{BOD} = 7.29(I)+41.82$	, ($r^2= 0.9$)	, ($p<0.001$)	(Eq. 6)

Y_{water1}, Y_{water2} & Y_{water3} represent estimation of water consumption on the basis of temperature and economical income(litre/cap./day) and T represents temperature(^{o}C) and I represents monthly income (100000 Tomans ≈ $ 100).

Y_{waste1} & Y_{waste2} represent estimation of generated wastewater on the basis of temperature variation (liter/cap./day).

Y_{BOD} represents biodegradable organic matter as a BOD_5 (g/cap./day)

The mean values of Biochemical Oxygen Demand (BOD_5) concentrations were 283 ±133, 305±136, and 327± 141 mg/liter in the regions, Kasra, Ellahiah and Taavon, respectively. In each area Pearson Correlation (r^2) between BOD and COD were found to be 0.98, 0.95 and 0.91; on the other hand the mean ratios of BOD/COD are 0.56, 0.58 and 0.55, in Kasra, Ellaheiah and Taavon respectively ($p_{value}< 0.01$). The results are summarized in the following tables:

Table 1: The Characteristics of Water Consumption, Generated Wastewater Estimation and its BOD Concentration Models.

Equation	Income coefficient	Cte.	Temperature coefficient	Percentage of Effectivity,(r^2)	P_{Value}
1	-	8.17	9.44	0.37	0.001
2	6.03	48.89	9.44	0.71	0.001
3	118.51	26.2	-	0.98	0.001
4	-	107.67	4.46	0.45	0.001
5	22.66	57.81	4.47	0.71	0.001
6	7.29	41.82	-	0.9	0.001

Table 2: Water Consumption, Generated Wastewater, Monthly Income and Organic Load in Three Areas

Paramet. Area	Load BOD g/cap./day	Wastewater lit./capita/day Mean		Water lit./cap./day Mean		Month.Income. Mean	Utilyzer Pop. Mean	Number of Utilyzer	Population	P_{Value}
		Winter	Summer	Winter	Summer					
Elahiah	62.4	158 (31)	204 (15)	188 (35)	291 (48)	2 (0.5)	5.5	6825	37537	0.001
Taavon	56	112 (29)	170 (34)	140 (48)	188 (50)	1.4 (0.7)	6	5053	30318	0.001
Kasra	62	170 (21)	220 (60)	200 (25)	398 (75)	3.2 (0.75)	5	4988	24940	0.001

Table 3: Mean, (SD), Correlation Coefficient of BOD, COD and Their Ratio of Wastewater in three Regions.

	$BOD \div COD$ ratio (SD)	Pearson(r)	Mean COD (mg/l) (SD)	Mean BOD_5 (mg/l) (SD)	P value
Ellahiah	0.58(0.097)	0.95	543(270)	305(136)	0.001
Taavon	0.58(0.09)	0.91	606(282)	327(141)	0.001
Kasra	0.56(0.06)	0.98	514(269)	283(133)	0.001

Discusion

The results show a significant relationship between water consumption and socio-economical status. This relationship is more obvious in the summer than the winter. Differences in water consumption, can be caused by washing of surfaces, irrigation of private gardens and other health purposes. The results are in agreement with those of the Brazilian Urban Communities study(Murdes, F. Neto *et al*., 2005). Inaddition this study indicates that water consumption in Kasra area with more suitable socio-economical status is much more than other areas. Wastewater generation does not show any significant difference in three areas statistically. This may be due to some parameters such as construction, green yards and private gardens. Although water consumption is quite different in these areas, but the generated wastewater does not

differ significantly. In fact in wealthy area a part of consumed water is absorbed by the land, and a part flows in the streets and alleys and does not account for wastewater. The percentage of collected wastewater in Kasra was 50-70 % of the water consumption in that area. There is not considerable agreement between this percentage and that cited in the literature (Tchobanoglous, *et al*., 2003). While, the generated wastewater in the mid-wealthy area was around 89% of the water consumption. The generated wastewater in Tavoon was about 90 percent of water consumption in warm weather. The generated wastewater due to water consumption in the last two areas was in agreement with the text book of wastewater engineering(Tchobanoglous *et al*., 2003). The percentage of generated wastewater were the same in warm and cold climates in two of tow above areas namely Ellahieh and Taavon. On the other hand, in the wealthy area of Kasra this percentage was increased in winter to about 80 – 85%. An increasing of about 30%depends on climatic variations; as water consumption increases in the summer. The result of this study almost entirely comply with that of Nabi Pour's research(2002) in the great Tehran. Overall water consumption is affected totally about 70% by two parameters, namely climatic and economical conditions.

In this study a regression modeling is involved in order to make estimation of water consumption and biochemical oxygen demand(BOD), which influence the quality of generated wastewater. In the view point of the relationship between water consumption and the monthly income, there is an agreement between the results of this study with that of Campose and Sperling(1996), of course, this agreement was not satisfied for BOD concentration in wastewater. Because of the low water consumption, the concentration of wastewater was high in the poor area, and this is also in agreement with the results of Nashashibi and van Dewichi, (1995) in Plastine. The effect of economical status on water consumption in this study complies with the result of Al-Humoud (2002).

In spite of statistical fluctuations, the results of this study does not indicate significant difference in BODs and CODs in three mentioned areas, it can be mentioned that in terms of BODs and CODs concentration, these wastewater could be classified as medium to strong. The ratios BODs and CODs are considered to be "good"(0.5-0.6), that is more than 55% of the organic carbonaceous substances is biodegradable, this ratio is more than that of the other researchers reports (Pons, *et al.*, 2004).

Conclusion

This study reveals a relationship between water consumption, wastewater generation and the corresponding BODs and those of socioeconomic status and climate conditions. In addition, the water consumption was influenced by monthly income, climate condition and their combination of these two parameters in such way that 90%, 30% and 70% were accounted for, respectively. Biological treatment capability of generated wastewater was considered to be "good" theoretically. The results show more than 555 of carbonaceous organic material is biodegradable.

Acknowledgement

I wish to express my deep gratitude to Mr Mozafar Safari, the manager of water and Wastewater Company for his helpful attention to prepare facilities for implementation of this comprehensive research thanks to research and educational affair of Shahid Abbaspoor electricity and water industry faculty, to confirm this research project and providing its budget. My thanks are due to Mr. Roholah Zivari Athar and Mr. Allah Reza Azizi B.S students of environmental health from Health College of KUMS for their seriously attempts in collecting some parts of data, used in this study.

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