Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

Vol. 8	No. 1	pp. 141-145	2009

Original Research Paper

A Correlation Study on Physico-Chemical Characteristics of Domestic Sewage

K. R. Venkatesh, M. Rajendran and A. Murugappan*
Deptt. of Civil Engineering, CAS in Marine Biology, Annamalai University, Parangipettai-608 502, Dist. Cuddalore, Tamil Nadu, India
*Deptt. of Civil Engineering, Annamalai University, Annamalai Nagar-608 002, Tamil Nadu

Key Words:
Domestic sewage
Physico-chemical characteristics
Correlation analysis

ABSTRACT

Urban environmental management is one of the most pressing issues as the urbanization trend continues globally. Among the challenges faced by urban planners is the need to ensure ongoing basic human services such as the provision of water and sanitation. The under-management of domestic sewage in many urban areas presents a major challenge. Prior to the selection of suitable treatment, the physico-chemical characteristics of domestic sewage have to be studied. From the city Chidambaram of Tamilnadu, domestic sewage samples were collected and analysed. Some of the parameters exceed the permissible limit for discharging in to surface waters prescribed by Central Pollution Control Board of India. A correlation analysis has been carried out among the parameters. The analysis is awfully realistic in wastewater management as well as safe disposal strategies.

INTRODUCTION

In developing countries like India where access to safe drinking water is not guaranteed for a majority of the population, it is of great importance to maintain the quality of surface water sources (Banu et al. 2007). In India, water pollution comes from three main sources, domestic sewage, industrial effluents and run-off from agriculture. With fast industrialization and urbanization in the world, the use of water increases continuously, hence, amount of domestic sewage also increases. It is estimated that 22900 million litres per day (MLD) of domestic sewage is generated from urban centres against 13500 MLD industrial effluents. The treatment capacity available for domestic wastewater is only for 5000 MLD against 8000 MLD of industrial wastewater. Thus, there is a big gap in treatment of domestic sewage. The process of urbanization in India since the beginning of last century reveals a steady increase in the size of its urban population, number of urban centers, and level of urbanization since 1911 onwards and a rapid rise after 1951. From a modest base of 25.8 million persons in 1901, the number of urban dwellers has risen to 285 million, signalling a phenomenal eleven-fold increase in urban population over the period 1901 2001. Due to rapid urbanization huge volume of domestic sewage is being disposed off into surface water bodies causing serious threat to aquatic organisms and human health. Also, indiscriminate disposal of sewage causes soil and groundwater contamination, which in turn adversely affect plants and animals (Kisku et al. 1998).

The population of India is likely to be stabilized by 2050 at the level of 1700 million people. As per the census of 2001 the urban population is 285 million, and keeping in view of population projection for the year 2051, it is likely to be of the magnitude of 1093 million. Based on the projected population for the year 2051, the wastewater generation is going to be around 132000 MLD. As minimum dry weather flow of rivers is going to be reduced due to increase in population and as a result of increase in water requirements for various purposes, the sewage generation in any urban centre is going to adversely affect water supply of downstream located urban centers. In view of such situation there is a need to attain 100% wastewater treatment in each city with more stringent standard.

Domestic sewage treatment consists of an item that deserves ample documentation due to environmental impact caused by such wastewater if directly discharged into receiving waters. In addition, due to increase in the scarcity of clean water, there is need for appropriate management of available water resources. Some of the goals of environmental protection and resource conservation concepts are the reuse of treated wastewater, residues emanating there from, and other treatment by-products. Consequently, by implementing these concepts, a wastewater like domestic sewage, apart from being sanitized, can become an important source of reusable water, fertilizer, soil conditioner and energy (Lettinga et al. 2001).

Domestic sewage is a low-strength wastewater characterized by high fraction of suspended solids (Van Lier et al. 2001). Generally, sewage has a chemical oxygen demand (COD) below 1000 mg/L but also contains heavy metals and other inorganic compounds which are often hazardous or toxic. The urban India has become a massive and perhaps a frightening reality as far as waste management is concerned. The number of studies dealing with the treatment of low-strength wastewater is increasing rapidly. In recent years there has been an attempt to conduct a survey and obtain baseline environmental status of a region and to determine the role played by various agencies to this issue for improving and preserving the environment. Establishment of constant relationships among the various constituents depends primarily on the nature of wastewater and its source. Because of the rapidity with which the related tests can be conducted, it is anticipated that more use will be made of these terms in future (Metcalf & Eddy 1995). Hence, it is necessary to determine the physico-chemical characteristics of such types of wastes. Thus, it has been considered prudent to investigate the condition of domestic sewage generated from any town. The analysis assists in rapid analysis of water quality and also in wastewater management.

MATERIALS AND METHODS

Domestic sewage was collected at selected locations from the main sewers during May to November 2007 from the city of Chidambaram, Tamilnadu. The samples were preserved under low temperature until testing was done. Quality control was ensured using standards while performing analysis. All the parameters were analysed following standard methods (APHA 1998). COD was determined by open reflux method. The various statistical parameters such as minimum, maximum, mean, standard deviation, variance and correlation coefficient have also been established. When the numerical value of the correlation coefficient ‘r’ between two variables is high, it indicates that two variables are highly correlated. For those pairs, a linear relation of the form $y = ax + b$ was established. Where a and b are the constants determined by fitting the experimental data by normal equations.

RESULTS AND DISCUSSION

The results of the various physico-chemical parameters, minimum, maximum, mean, standard deviation and variance are presented in Table 1.

The average pH value of the sewage is slightly alkaline in nature. Electrical conductivity of the sewage is due to the presence of dissolved salts and solids. Turbidity is caused by the presence of dirty dish water from bathrooms, piece of papers, vegetable skins, fruit skins, etc. The temperature of

Table 1: Statistical values for various characteristics of sewage samples.

Parameters*	Minimum	Maximum	Mean	SD	Variance
pH	6.96	7.35	7.13	0.15	0.0225
Electrical Conductivity (EC)	1.26	1.46	1.356	0.086	0.0074
Turbidity	46	56	50.4	3.85	14.8225
Temperature(Temp)	28.5	33	30.56	1.7	2.8900
Total Solids (TS)	980	1122	1050	64	4096.0000
Total Suspended Solids (TSS)	162	184	168	8.07	65.1249
Total Dissolved Solids (TDS)	818	952	882	58.73	3449.2129
Volatile Suspended Solids (VSS)	120	138	131	6.8	46.2400
Chlorides	362	460	388	36.61	1340.2921
Alkalinity (as $CaCO_3$)	120	210	153.6	42.97	1846.4209
Biochemical Oxygen Demand $(BOD)_3$ 27°C	386	586	520	77.33	5979.9289
Chemical Oxygen Demand (COD)	628	920	828	110.33	12172.7089
Ammonical Nitrogen (as N)	9	12	9	1.3	1.6900
Total kjeldahl Nitrogen (TKN)	12	16	1.2	1.78	3.1684
Dissolved Phosphate (as P)	0.6	1	0.8	0.148	0.0219

*All values expect pH, EC (mmho/cm), turbidity (NTU) and temperature (°C) are in mg/L.

Table 2: Correlation coefficient (r-values) matrix among various parameters of sewage.

	pH	EC	Turbidity	Temp.	TS	TSS	TDS	VSS	Chlorides	Alkalinity	BOD	COD	N	TKN	P
pH	1	0.8364	0.1100	0.3891	0.7995	0.1732	0.8473	0.1939	0.3796	0.7172	0.2688	0.2102	0.5366	0.5373	0.8667
EC		1	0.5451	0.7876	0.8917	0.6057	0.9969	0.4509	0.9466	0.9527	0.2505	0.1252	0.5612	0.8149	0.6332
Turbidity			1	0.5556	0.6166	0.9791	0.5373	0.8948	0.3847	0.5334	0.4694	0.5734	0.3788	0.6668	0.1048
Temp				1	0.1506	0.4003	0.2193	0.3067	0.2641	0.0282	0.5728	0.6252	0.3567	0.3655	0.2343
TS					1	0.6878	0.8949	0.5365	0.9193	0.9222	0.1920	0.0640	0.5022	0.7870	0.5805
TSS						1	0.5894	0.8964	0.4214	0.5608	0.3163	0.4447	0.2565	0.6092	0.0670
TDS							1	0.4714	0.9437	0.9277	0.2527	0.1311	0.5119	0.7738	0.6233
VSS								1	0.3740	0.3135	0.6136	0.7003	0.2481	0.4565	0.2032
Chlorides										1	0.8749	0.1584	0.0608	0.6828	0.7923
0.8451															
Alkalinity										1	0.1612	0.1697	0.6532	0.8962	0.5632
BOD											1	0.9883	0.2736	0.1005	0.1122
COD												1	0.3489	0.2295	0.1483
N													1	0.8789	0.2533
TKN														1	0.6407
P															1

sewage is generally higher than that of utilized water. However, the temperature is more, the dissolved oxygen in the sewage gets reduced. Chlorides are derived from kitchen waste and urinary discharges. Alkalinity is due to the presence of carbonates and bicarbonates of calcium and magnesium derived kitchen wastewater. Alkalinity may also be caused due to evolution of carbon dioxide during decomposition of organic matters. Ammonical nitrogen and TKN is derived from proteins in food wastes and also formed due to intermediate stage in the conversion of organic matter. Phosphate is derived from kitchen wastewater and urinal discharge. BOD and COD are due to presence of organic matter present in sewage mainly in the form of food waste. The BOD/COD ratio indicates that the sewage is amenable for easier biodegradation. The parameters like TSS, BOD and COD exceed the permissible limit prescribed by CPCB for disposing the sewage into inland surface water which needs treatment before disposal.

Table 3: Least square fitting of relation. y = *a*x + *b* among significantly correlated pairs of parameters.

x	*y*	*r*	r^2	*a*	*b*
EC	TDS	0.9969	0.9938	674.77	-28.785
BOD	COD	0.9883	0.9767	1.410	79.438
Turbidity	TSS	0.9791	0.9586	2.0541	67.676
EC	Alkalinity	0.9527	0.9076	471.85	-486.22
EC	Chlorides	0.9466	0.8960	399.47	-134.08
TDS	Chlorides	0.9437	0.8906	0.5884	-113.27

Table 4: Comparison of observed and predicted values of parameters.

Parameter (*y*)	(*x*)	Observed value	Expected value
TDS	EC	882	886.203
COD	BOD	828	812.638
TSS	Turbidity	168	171.20
Alkalinity	EC	153.6	153.61
Chlorides	EC	388	407.60
Chlorides	TDS	388	405.7

The correlation coefficient (r-values) for various physico-chemical parameters were established and presented in Table 2. The r-value varies in the range of 0.0608 to 0.9969 depending on the set of parameters considered for analysis. The correlation values above 0.94 were selected for analysis. The highest correlation is between EC and TDS. High positive correlations between Turbidity and TSS, BOD and COD, EC and chlorides were also observed. The linear relationships between various parameters are presented in Table 3. A comparison, made between the observed value and expected values for the highly correlated pairs, is also presented in Table 4.

Similar work done by various researchers with different types of wastewaters and groundwater have also been studied. They also achieved some significance from the data analysis. Arutchelvan et al. (2004) found significant linear relationships between EC-TDS; TDS-chlorides; TDS-sulphates, EC-chlorides and EC-sulphates while analysing the physico-chemical characteristics of wastewater from Bakelite manufacturing industry. High correlation coefficients were obtained between TDS-EC; TDS-chlorides and chlorides-EC by Govindaradjane et al. (2007) in analysing the physico-chemical characteristics of effluents from a pharmaceutical industry. A correlation study on physico-chemical characteristics of groundwater reported by Venkatasubramani et al. (2006) depicts high positive correlation between total hardness and magnesium; TDS and chlorides and TDS and magnesium.

There are currently a large number of papers reporting results of treatment of domestic sewage with each paper referring different range of characteristics of sewage depending on local climatic conditions, topography, living standard and habitat of the people as well as type of treatment adopted. Thus, the significance of established correlation coefficient for the global application for different types of wastewater is still in question. At the same time while designing a reactor for secondary biological treatment, fluctuations in the concentrations like BOD, COD, pH, TSS, alkalinity, chlorides and temperature, etc. of the wastewater were evaluated based on the variance and SD. It was applied to the data obtained from the influent and effluent of the reactors in order to access whether operational conditions cause distinct effect on the performance of the reactors (Sokal & Rohlf 1973).

Thus, the analysis and the finding of the coefficient assist in rapid analysis in wastewater treatment and management.

CONCLUSION

Following conclusions are drawn from the present investigation.

1. The parameters like BOD, COD and TSS exceed the permissible limit prescribed by Central Pollution Board for disposing the sewage into surface water.
2. Temporal variations exist in the concentration of most of the constituents of sewage.
3. The parameters like EC-TDS, BOD-COD, Turbidity-TSS, TDS-chlorides have a good correlation and the equations obtained are very useful in the rapid analysis of domestic sewage. It helps in establishing water quality modelling and technological options for new treatment technologies.
4. The equations may be fitted to any other set of parameters having similar characteristics in order to evaluate the significance.

ACKNOWLEDGMENT

The corresponding author is thankful to the authorities of Annamalai University for providing necessary facilities to carry out the this research work.

REFERENCES

Arutchelvan, V., Kanakasabai, V., Elangovan, R. and Nagarajan, S. 2004. Physico-chemical characteristics of wastewater from Bakelite manufacturing industry. Indian J. Environ. & Ecoplan., 8(3): 757-760.

Banu, J.R., Kaliappan, S. and Yeom, I.T. 2007. Treatment of domestic wastewater using upflow anaerobic sludge blanket reactor. Int. J. Environ. Sci. Tech., 4(3): 363-370.

Govindaradjane, S., Sundararajan, T., Sivamurthy Reddy, S. and Sivasankaran M.A. 2007. Physico-chemical characteristics of wastewater from a pharmaceutical industry. Poll Res., 26(1): 131-133.

Kishku, G.C. and Bhargava, S.K. 1999. Water quality around Durgapur industrial belt, its impact on environment. Indian Journal of Environ. Protection, 18: 898-903.

Lettinga, G., Van Lier, J.B., Van Buuren, J.C.L. and Zeeman, G. 2001. Sustainable development in pollution control and the role of anaerobic treatment. Water Sci. Technol., 44: 181-188.

Metcalf and Eddy 1995. Wastewater - Treatment, Disposal and Reuse. Tata McGraw-Hill Publishers, New Delhi.

Sokal, R.R. and Rohlf, F.J. 1973. Introduction to Biostatistics. San Francisco, Freeman.

APHA 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed., American Public Health Association, Washington.

Van Lier, J.B., Tilche, A., Ahring, B.K., Macarie, H., Moletta, R., Dohanyos, M., HulshoffPol, L.W., Lens, P. and Verstraete, W. 2001. New perspectives in anaerobic digestion. Water Sci. Technol., 43(1): 1-18.

Venkatasubramani, R., Meenambal, T. and Livingston Peter Goldwyn 2006. A correlation study on physico-chemical characteristics of ground waters in Coimbatore district. Poll. Res., 25(2): 371-374.