Measurement of Organic Content in Municipal Waste Water of Gulbarga City

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Abstract— A study was undertaken to assess the characteristics like physical and chemical analysis of the wastewater of Gulbarga city. The characteristics involves the analysis of total solids, suspended solids, dissolved solids, volatile solids, biological oxygen demand, chemical oxygen demand, phosphates, ammonical nitrogen, nitrites, nitrates. The study was carried out for 6 different sources of discharge in the Gulbarga city comprising residential, commercial and educational institutional areas. After analyzing the physico chemical characteristics suitable interpretation analysis is carried out by statistical calculation viz. mean, standard deviation, coefficient of variation, correlation coefficient, rate of reaction and regression analysis are worked out. The present study shows the waste water is organic in nature having average values of BOD of 444 mg/l, COD of 815 mg/l, total solids of 1401 mg/l, dissolved solids of 1146 mg/l and suspended solids of 255 mg/l. Since BOD/COD ratio of all the sampling points lies near the the range of generally accepted ratio of 0.6, the average ratio of 0.55 for A1 to A6 are found, hence it is concluded that sewage is organic in nature and waste can be treated biologically.

Key words: Waste water, reaction rate, BOD, COD

I. INTRODUCTION

A. Municipal Wastewater Refers To Domestic Waste Water (Sewage):

Municipal wastewater refers to domestic waste water (sewage) or a mixture of domestic wastewater and industrial wastewater (also referred to as trade effluent) and/or urban storm water run-off. The characteristics of municipal wastewaters vary from location to location depending upon the sources of discharge, the effluents from industries, land uses, groundwater levels, and degree of separation between storm water and sanitary wastes. Domestic wastewater includes typical wastes from the kitchen, bathroom, laundry, as well as any other wastes that people may accidentally or intentionally pour down the drain. Industrial effluents originate from product processing or cooling water. Infiltration; inflow; and/or storm water runoff also contribute to the pollutant load of municipal wastewaters.

Organic materials are found everywhere in the environment. They are composed of the carbon-based chemicals that are the building blocks of most living things. Organic materials in wastewater originate from plants, animals, or synthetic organic compounds, and enter wastewater in human wastes, paper products, detergents, cosmetics, foods, and from agricultural, commercial, and industrial sources.

Organic compounds normally are some combination of carbon, hydrogen, oxygen, nitrogen, and other elements. Many organics are proteins, carbohydrates, or fats and are biodegradable, which means they can be consumed and broken down by organisms. However, even biodegradable materials can cause pollution. In fact, too much organic matter in wastewater can be devastating to receiving waters.

Domestic sewage has 99.9% water and 0.1% solids on evaporation. About two thirds of the solids are organic, comprising mainly of nitrogenous compounds Carbohydrates, Fats. The inorganic compounds include chlorides, metallic salts, ash, road grit etc. The main constituent of domestic sewage can be listed as solids, chlorides, alkalinity, biological oxygen demand, chemical oxygen demand, nitrogen, phosphates, sulphates etc. The organic matter present in the wastewater is described in terms of biological oxygen demand (B.O.D) and suspended solids (S.S). The B.O.D refers to the quantity of oxygen used in the biochemical oxidation of organic matter. The quantity of oxygen used is related to the duration and temperature of the process. Usually this is five days demand at 20° C and is expressed as milligrams per litre (mg/L).

B. Objectives Of The Study:

This study was carried out with the following objectives,

- To study the physical, chemical characteristics like TS, VS, BOD, COD, Nitrogen, Phosphorous of municipal wastewater
- To determine the BOD/COD ratio
- To determine the standard deivation, coefficient of variation
- To determine BOD reaction rate constant k
- To establish the correlation between TS, TDS, TSS, BOD, COD of waste water
- To fit the regression equation

II. MATERIALS AND METHODOLOGY

A. During The Period Of Study, Samples Were Collected On Weekly Basis By Grab Sampling In Five Litres Sterile Dark Colored Containers. Waste Water Sample Was Collected At Areas A1 To A6 Of Gulbarga City As Shown Below:

AREAS CONSIDERED	
Commercial Area – A1	Market Area
Residential Area - A2	Sundar Nagar
Govt. Office and Educational Institution Area - A3	PDA College Road
Residential Area - A4	Basava Nagar
Residential Area - A5	Santosh Colony
Residential Area - A6	Khuba Plot

Table 1: Areas considered for study

The wastewater is collected at the point where the water depth is one third from the bottom and the container

was immersed below the surface of the waste water and was transferred to the laboratory and is stored in the deep freezer. Special preservations methods are necessary for portions that are not to be analyzed immediately by adding special chemicals for certain tests as shown below.

PARAMETERS	PRESERVATIVES	MAXIMUM HOLDING PERIOD
BOD	Refrigeration at 4°c	6 hours
COD	2ml per litre of H_2SO_4	7 days
Nitrogen, Ammonia	40mg/l $HgCl_2$	7 days
Nitrogen, Nitrate-Nitrite	40mg/l $HgCl_2$	7 days
Phosphorous	40mg/l $HgCl_2$	7 days
Solids	-	-

Table 2: Parameters and corresponding preservatives

B. Analysis Of Physico-Chemical Characteristics Of Wastewater:

The physicochemical characteristics analyzed are;

(1) Biological Oxygen Demand – BOD in mg/l
(2) Chemical Oxygen Demand – COD in mg/l
(3) Total Solids in mg/l
(4) Total Dissolved Solids mg/l
(5) Total Volatile Solids in mg/l
(6) Total Suspended Solids mg/l
(7) Nitrite in mg/l
(8) Nitrate in mg/l
(9) Ammonical Nitrogen in mg/l
(10) Phosphate in mg/l

C. Methods Of Examination:

(1) Total solids in sewage sample by gravimetric method in mg/l
(2) Nitrate of sewage sample by using spectrophotometer in mg/l
(3) Nitrite of sewage sample by using spectrophotometer in mg/l
(4) Phosphate of sewage sample by using spectrophotometer in mg/l
(5) BOD by Wrinkler's method in mg/l
(6) COD by Dichromate Reflux Method in mg/l

III. Results and Discussion

A. The Physico-Chemical Characteristics Of Municipal Wastewater For 20 Samples Each Of Areas A1 To A6 Have Been Studied And Average Characteristics Are Tabulated In The Table 3:

Sl.No.	Parameters										
	BOD (mg/l)	COD (mg/l)	TS (mg/l)	TDS (mg/l)	TVS (mg/l)	TSS (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Ammonical Nitrogen (mg/l)	Phosphate (mg/l)	BOD/COD
1	451	815	1379	1124	667	254	3.26	12.36	18.43	3.01	0.56
2	432	780	1392	1123	562	269	2.65	11.82	18.83	2.55	0.56
3	451	857	1389	1139	538	250	2.75	12.34	20.15	2.35	0.53
4	452	842	1403	1139	583	264	2.76	11.91	20.40	2.19	0.54
5	433	802	1417	1177	517	239	2.80	11.79	17.08	2.14	0.54
6	455	826	1416	1170	508	246	3.06	12.60	20.40	2.00	0.55
7	456	820	1390	1137	562	253	3.27	11.71	20.35	2.25	0.56
8	452	831	1393	1114	520	280	3.33	11.69	20.73	2.64	0.54
9	413	753	1409	1133	488	276	2.94	11.95	19.69	2.00	0.55
10	432	791	1407	1189	514	217	3.16	12.25	17.42	2.07	0.55
11	433	766	1427	1142	542	285	2.98	11.69	17.69	1.95	0.56
12	429	788	1362	1117	514	245	2.92	11.91	20.00	2.19	0.55
13	437	790	1411	1144	531	267	2.61	12.06	21.75	1.90	0.55
14	443	842	1393	1120	496	274	2.86	11.44	18.61	2.45	0.53
15	449	844	1397	1158	490	238	3.20	12.49	18.98	2.02	0.53
16	445	823	1423	1157	551	266	2.57	12.13	17.23	2.21	0.54
17	447	815	1400	1182	486	218	3.19	12.09	18.33	2.16	0.55
18	458	864	1384	1149	510	235	2.79	11.98	18.92	2.27	0.53
19	462	833	1424	1191	489	233	2.53	11.60	18.25	2.27	0.56
20	447	820	1402	1115	529	288	3.17	11.54	19.08	1.98	0.55
Maximum	462	864	1427	1191	667	288	3.33	12.60	21.75	3.01	0.56
Minimum	413	753	1362	1114	486	217	2.53	11.44	17.08	1.90	0.53
Mean	444	815	1401	1146	530	255	2.94	11.97	19.12	2.23	0.55
S.D	12.21	29.84	16.33	25.07	42.30	20.98	0.25	0.32	1.29	0.27	0.01
C.V	0.028	0.037	0.012	0.022	0.080	0.082	0.087	0.027	0.067	0.121	0.019

Table 3: Average Characteristics Of WasteWater(A1-A6)

From Table 3, the average 5 day BOD is observed to be 444 mg/l. Whereas the BOD in the typical composition of untreated domestic waste water is the range of 110 to 350 mg/l. So the waste water is highly organic in nature. The

typical composition of COD in raw sewage is in the range of 250 to 800 mg/l against the value of 815 mg/l which almost within the acceptable limits. The mean value of BOD to COD ratio is found to be 0.55.

The waste water solids may be classified into total solids, suspended solids and volatile solids. In general the concentration of total solids in untreated wastewater as per Indian condition is from 350 to 1300mg/l. The average value of total solids as shown in table 3 of gulbarga city is 1400 mg/l which is in the general concentration of domestic sewage.

Ammonical Nitrogen content in the untreated sewage is observed to be in the range of 12 to 45 mg/l. Nitrogen being an essential component of biological protoplasm, its concentration is important for proper functioning of biological treatment systems and disposal on land. The mean value of ammonical nitrogen content of is 19 mg/l which indicates that the sewage is weak in its nitrogen content.

B. Calculation Of Coefficient Of Correlation:

In the present study area, the correlation coefficient (r) between every parameter pairs is computed by taking the values of various parameters from A1 to A6. Correlation coefficient (r) between any two parameters, x & y is calculated for various parameters as discussed above. The degree of line association between any two of the waste water parameters as measured by the simple correlation coefficient (r) for the area A1 to A6 is presented in the Table 4 to Table 10, as 10 x 10 correlation matrix.

Sl.No.	Parameters	BOD	COD	TS	TDS	TVS	TSS	Nitrite	Nitrate	Ammonical Nitrogen	Phosphate
1	BOD	-	0.41	-0.02	0.07	0.19	-0.13	0.06	0.05	-0.10	-0.65
2	COD	0.41	-	0.14	0.08	0.23	0.01	0.36	-0.07	-0.14	-0.15
3	TS	-0.02	0.14	-	0.79	-0.12	-0.25	0.28	0.09	-0.19	-0.28
4	TDS	0.07	0.08	0.79	-	-0.27	-0.80	0.25	0.05	-0.03	-0.33
5	TVS	0.19	0.23	-0.12	-0.27	-	0.30	-0.01	-0.12	0.18	-0.03
6	TSS	-0.13	0.01	-0.25	-0.80	0.30	-	-0.11	0.00	-0.14	0.24
7	Nitrite	0.06	0.36	0.28	0.25	-0.01	-0.11	-	0.11	-0.12	0.07
8	Nitrate	0.05	-0.07	0.09	0.05	-0.12	0.00	0.11	-	-0.23	-0.15
9	Ammonical Nitrogen	-0.10	-0.14	-0.19	-0.03	0.18	-0.14	-0.12	-0.23	-	0.23
10	Phosphate	-0.65	-0.15	-0.28	-0.33	-0.03	0.24	0.07	-0.15	0.23	-

Table 4: Coefficient of correlation of waste water for A1

Sl.No.	Parameters	BOD	COD	TS	TDS	TVS	TSS	Nitrite	Nitrate	Ammonical Nitrogen	Phosphate
1	BOD	-	0.63	0.07	-0.02	0.45	0.07	0.47	0.53	0.03	-0.25
2	COD	0.63	-	-0.34	-0.37	0.38	0.19	0.39	0.07	-0.08	0.20
3	TS	0.07	-0.34	-	0.49	0.21	0.11	0.13	0.28	-0.12	-0.43
4	TDS	-0.02	-0.37	0.49	-	-0.06	-0.81	-0.07	0.36	-0.21	-0.21
5	TVS	0.45	0.38	0.21	-0.06	-	0.21	0.12	0.34	-0.16	-0.14
6	TSS	0.07	0.19	0.11	-0.81	0.21	-	0.16	-0.22	0.16	-0.04
7	Nitrite	0.47	0.39	0.13	-0.07	0.12	0.16	-	0.36	0.22	-0.15
8	Nitrate	0.53	0.07	0.28	0.36	0.34	-0.22	0.36	-	0.06	-0.38
9	Ammonical Nitrogen	0.03	-0.08	-0.12	-0.21	-0.16	0.16	0.22	0.06	-	-0.24
10	Phosphate	-0.25	0.20	-0.43	-0.21	-0.14	-0.04	-0.15	-0.38	-0.24	-

Table 5: Coefficient of correlation of waste water for A2

Sl.No.	Parameters	BOD	COD	TS	TDS	TVS	TSS	Nitrite	Nitrate	Ammonical Nitrogen	Phosphate
1	BOD	-	0.79	-0.32	-0.22	0.05	-0.01	0.43	-0.13	0.13	0.49
2	COD	0.79	-	-0.28	-0.13	0.20	-0.08	0.21	-0.41	-0.15	0.32
3	TS	-0.32	-0.28	-	0.45	0.18	0.29	-0.14	-0.08	0.19	-0.20
4	TDS	-0.22	-0.13	0.45	-	-0.04	-0.72	0.01	-0.06	-0.12	-0.32
5	TVS	0.05	0.20	0.18	-0.04	-	0.19	-0.28	0.11	0.31	0.49
6	TSS	-0.01	-0.08	0.29	-0.72	0.19	-	-0.11	0.00	0.28	0.19
7	Nitrite	0.43	0.21	-0.14	0.01	-0.28	-0.11	-	0.03	0.09	0.15
8	Nitrate	-0.13	-0.41	-0.08	-0.06	0.11	0.00	0.03	-	0.61	0.21
9	Ammonical Nitrogen	0.13	-0.15	0.19	-0.12	0.31	0.28	0.09	0.61	-	0.20
10	Phosphate	0.49	0.32	-0.20	-0.32	0.49	0.19	0.15	0.21	0.20	-

Table 6: Coefficient of correlation of waste water for A3

Sl.No.	Parameters	BOD	COD	TS	TDS	TVS	TSS	Nitrite	Nitrate	Ammonical Nitrogen	Phosphate
1	BOD	-	0.86	0.05	0.11	0.01	-0.11	-0.35	-0.12	0.00	-0.34
2	COD	0.86	-	0.24	0.34	-0.15	-0.25	-0.48	-0.16	0.01	-0.44
3	TS	0.05	0.24	-	0.75	-0.06	0.00	0.00	0.05	0.16	-0.18
4	TDS	0.11	0.34	0.75	-	0.13	-0.66	-0.11	0.10	0.09	-0.22
5	TVS	0.01	-0.15	-0.06	0.13	-	-0.26	0.04	-0.11	0.25	0.51
6	TSS	-0.11	-0.25	0.00	-0.66	-0.26	-	0.17	-0.09	0.05	0.12
7	Nitrite	-0.35	-0.48	0.00	-0.11	0.04	0.17	-	-0.05	0.04	0.15
8	Nitrate	-0.12	-0.16	0.05	0.10	-0.11	-0.09	-0.05	-	-0.22	0.01
9	Ammonical Nitrogen	0.00	0.01	0.16	0.09	0.25	0.05	0.04	-0.22	-	0.31
10	Phosphate	-0.34	-0.44	-0.18	-0.22	0.51	0.12	0.15	0.01	0.31	-

Table 7: Coefficient of correlation of waste water for A4

Sl.No.	Parameters	BOD	COD	TS	TDS	TVS	TSS	Nitrite	Nitrate	Ammonical Nitrogen	Phosphate
1	BOD	-	0.92	-0.43	-0.36	-0.07	-0.17	0.03	0.12	0.24	-0.05
2	COD	0.92	-	-0.36	-0.31	-0.22	-0.13	-0.05	0.10	0.25	-0.07
3	TS	-0.43	-0.36	-	0.89	-0.44	0.33	0.04	-0.28	0.07	-0.40
4	TDS	-0.36	-0.31	0.89	-	-0.45	-0.14	0.21	-0.22	-0.06	-0.22
5	TVS	-0.07	-0.22	-0.44	-0.45	-	0.00	0.01	-0.11	-0.32	0.44
6	TSS	-0.17	-0.13	0.33	-0.14	0.00	-	-0.34	-0.14	0.27	-0.40
7	Nitrite	0.03	-0.05	0.04	0.21	0.01	-0.34	-	-0.31	-0.22	0.53
8	Nitrate	0.12	0.10	-0.28	-0.22	-0.11	-0.14	-0.31	-	0.10	-0.12
9	Ammonical Nitrogen	0.24	0.25	0.07	-0.06	-0.32	0.27	-0.22	0.10	-	-0.34
10	Phosphate	-0.05	-0.07	-0.40	-0.22	0.44	-0.40	0.53	-0.12	-0.34	-

Table 8: Coefficient of correlation of waste water for A5

Sl.No.	Parameters	BOD	COD	TS	TDS	TVS	TSS	Nitrite	Nitrate	Ammonical Nitrogen	Phosphate
1	BOD	-	0.87	0.01	-0.05	-0.17	0.33	0.02	-0.18	0.19	-0.03
2	COD	0.87	-	0.01	-0.02	-0.12	0.18	0.05	-0.15	0.09	-0.07
3	TS	0.01	0.01	-	0.99	0.29	-0.20	0.05	-0.07	-0.04	0.22
4	TDS	-0.05	-0.02	0.99	-	0.38	-0.35	0.13	-0.07	-0.13	0.25
5	TVS	-0.17	-0.12	0.29	0.38	-	-0.61	0.02	0.00	-0.66	-0.11
6	TSS	0.33	0.18	-0.20	-0.35	-0.61	-	-0.52	0.02	0.56	-0.25
7	Nitrite	0.02	0.05	0.05	0.13	0.02	-0.52	-	-0.12	-0.08	0.75
8	Nitrate	-0.18	-0.15	-0.07	-0.07	0.00	0.02	-0.12	-	-0.14	-0.21
9	Ammonical Nitrogen	0.19	0.09	-0.04	-0.13	-0.66	0.56	-0.08	-0.14	-	0.23
10	Phosphate	-0.03	-0.07	0.22	0.25	-0.11	-0.25	0.75	-0.21	0.23	-

Table 9: Coefficient of correlation of waste water for A6

From the tables 4 to 10, the highest positive coefficient of correlation is found to be 0.987 for A6 between the parameters total solids (TS) and Total dissolved solids(TDS) and the highest negative coefficient of correlation is found to be -0.81 for A2 between the parameters Total dissolved solids (TDS) and Total suspended solids (TSS). The high values of coefficient of correlation observed are used for the regression analysis for forming the regression equation as discussed in the following sections.

C. Regression Analysis:

Regression analysis is a statistical process for estimating the relationship among variables. It includes many techniques for modelling and analyzing several variables, when the focus is on relationship between a dependent variable and one or more independent variables. A response curve that follows a straight line is generally desired. The objective of regression analysis is to determine the value of a and b and their uncertainties. Table 10 below shows the regression line equations between two parameters showing highest coefficient of correlation for A1 to A6.

Areas Considered	x – axis	y – axis	n	x - mean	y - mean	σ_x	σ_y	r	$y_i = bx_i + a$
A1	Total Solids	Total Dissolved Solids	20	1594	1280	45.48	72.67	0.79	$y = 1.26\,x - 721.27$
A2	Total Dissolved Solids	Total Suspended Solids	20	1172	297	52.88	46.38	0.81	$y = 1.449\,x - 1401.43$
A3	BOD	COD	20	453	814	21.79	59.7	0.79	$y = 0.716\,x + 489.50$
A4	Total Dissolved Solids	Total Suspended Solids	20	1112	242	37.48	24.9	0.66	$y = 1.358\,x - 1268.67$
A5	BOD	COD	20	424	794	44.09	92.42	0.92	$y = 0.722\,x + 487.58$
A6	Total Solids	Total Dissolved Solids	20	1223	1032	73.04	76.46	0.99	$y = 0.745\,x + 120.57$

Table 10: Computation of Regression equation

D. Rate Of Reaction:

The rate constant k can be computed from BOD values measured at various times. The rate of reaction constant k is found for the sample A6. Bottle numbered 1 to 6 are analysed for incubation period ranging from 1 to 3 days. These data along with the average five day value for A6 are plotted in Figure 1. The variation of BOD time curve along with the average BOD_5 value of A6 is plotted in Figure 2.

Bottle No.	Waste Water Portion (ml)	Intial DO (mg/l)	Incubation Period (days)	Final DO (mg/l)	DO Drop (mg/l)	Calculated BOD (mg/l)	$(Time/BOD)^{1/3}$
1	4.0	8.2	1	6.9	1.3	97.5	0.217
2	4.0	8.2	1	7.0	1.2	90.0	0.223
3	4.0	8.3	2	6.4	3.1	142.5	0.241
4	4.0	8.2	2	6.2	3.1	150.0	0.237
5	4.0	7.9	3	4.7	3.6	240.0	0.232
6	4.0	6.8	3	4.2	2.6	195.0	0.249

Average BOD_5 value for A6 = 368 mg/l

Table 11: BOD data analysis of waste water for A6

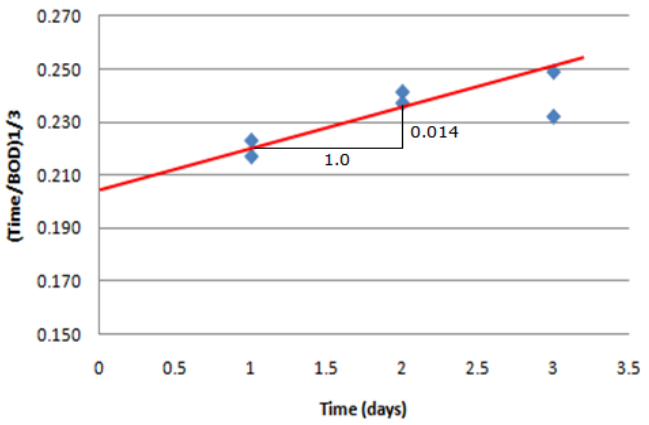

Fig. 1: BOD time curve

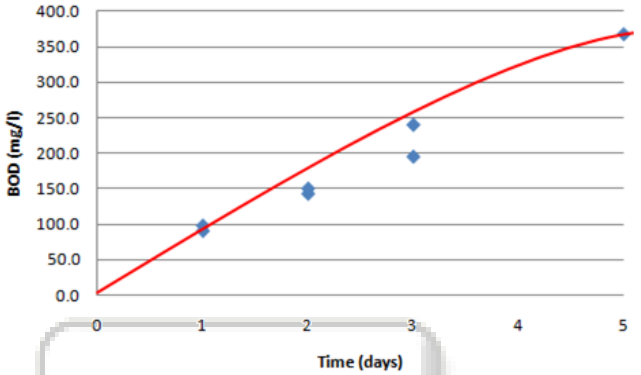

Fig. 2: BOD time curve with average BOD_5 value

From Figure 1, k=2.61xB/A
= 2.61 x 0.014 / 0.2
= 0.18 per day

IV. CONCLUSIONS

(1) It can be concluded from the study that the waste water is organic in nature having average values of BOD of 444 mg/l, COD of 815 mg/l, total solids of 1401 mg/l, dissolved solids of 1146 mg/l and suspended solids of 255 mg/l.
(2) Since BOD/COD ratio of all the sampling points lies near the the range of generally accepted ratio of 0.6, the average ratio of 0.55 for A1 to A6 are found, hence it is concluded that sewage is organic in nature and waste can be treated biologically.
(3) From the study rate of reaction constant 'k' is calculated to be 0.18 per day.

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