International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

A Comparative Study of BOD Rate Constant of Two Waste Water Samples

Manab Maiti , Subhanjan Majumder, Chandan Santra
Department of Chemistry, Brainware Group of Institutions, West Bengal, India,

ABSTRACT: *The BOD(Biochemical Oxygen Demand) is the amount of oxygen(O_2) in mg/lit or ppm(parts per million) to oxidize biodegradable organic waste by microorganisms aerobically. The reaction kinetics involved in degradation process of the the biodegradable organic matter with the help of microorganisms in the presence of dissolved oxygen(DO) and rejuvenation of the same in any water body may be first order or half order or half order second order or combination of them.* ***Assuming the first order one, a comparative study has been envisioned between the BOD rate constants K_1 of two waste-water samples, collected from two different sources in a municipality area.*** *Simultaneously, the other parameters e.g. pH, temperature, TSS, COD of the two waste water samples were determined using standard method to ascertain the characteristic features of the same.*

KEYWORDS:Municipal waste water, physic o-chemical parameters, BOD- rate constant, waste water treatment.

1. INTRODUCTION:

Water is essential for maintaining healthy ecosystem and for proper socio–economic development. With increase in population the demand of water for domestic, agriculture and industrial purpose, is also increasing. Over lifting of ground water is creating excessive pressure on the environment[1,2]. Also with the exponentially increasing population pressure huge amount of waste water is being generated. That is why wastewater treatment systems have drawn the interest of scientists in recent years[2,3].

As the waste water collected from various sources is contaminated, it should be treated so as to remove contaminants in order to be released again into their origin [4].The treatment must remove pathogens, **BOD materials**, excessive nutrients and toxic chemicals [4].

This paper focuses on the determination of BOD rate constant which is very crucial to know the nature of waste water which is discharged into a stream or any other water body [5]. The discharged waste water may severely affect the dissolve oxygen value of the stream or the water body that contains living system [5].

Self-purification of polluted streams or water bodies is affected by the kinetics of deoxygenation and reoxygenation[6]. Information on the oxygen-depleting characteristics of waste water can be obtained from the BOD reaction kinetics [5,7]. On the other hand this information can be utilized to design the waste water treatment plant [5,8].

2. BOD REACTION:

The simplified representation[4] of aerobic decomposition of organic matter can be given as

Organic matter + O_2 microorganism Products

It is to be noted that our discussion and mathematical formulation regarding BOD is solely due to carbonaceous biochemical oxygen(CBOD) demand and not nitrogenous biochemical oxygen demand (NBOD) which involves oxygen needed to convert biochemical ammonia to nitrate [4]. The reason being, NBOD does not normally begin for the initial five to eight days [7].

3. BOD EQUATION:

The reaction will be considered here as a first order kinetics, so the equation is:

$\mathbf{y_t = L\,(1- e^{-kt})}$……………………… (1)

y_t = the BOD consumed (mg/L) after time t.

L = the ultimate first stage BOD (mg/L)

k = the rate constant

t = time in days

Equation (1) could be written as

$\mathbf{y_{t+h} = L[1 - e^{-k(t+h)}]}$ where h = 1 day

$\mathbf{Or,\ y_{t+h} = L\ [1 - (e^{-kt} \times e^{-kh})]}$ …………… (2)

Substituting the value of e^{-kt} from equation (1) to equation (2), we have

$\mathbf{y_{t+h} = L\ [\ 1 - (L - y_t)/\ L\ .\ e^{-kh}]}$

$\mathbf{or,\ y_{t+h} = L\ [\ 1 - e^{-kh}] + y_t \times e^{-kh}}$…… (3)

Equation (3) could be rewritten as a straight line equation

$\mathbf{y_{t+h} = y_t \times e^{-kh} + L\ [1 - e^{-kh}]}$

Where: $\mathbf{L\ [1 - e^{-kh}]}$ = intercept of the line

$\mathbf{e^{-kh}}$= slope of the line

4. SOLUTION FOR K AND L [FUJIMOTO GRAPHICAL METHOD TO FIND UBOD (L)]:

$\mathbf{y_{t+h}}$was plotted against $\mathbf{y_t}$with the help of Microsoft Excel to solve the slope and intercept of the line and hence for K and L.

5. METHODOLOGY:

5.1. SAMPLE COLLECTION

The municipal waste water samples considered in this work were collected from two different sources (1-2 km apart from each other) of Tarapith a small temple town near Rampurhat in Birbhum district of the Indian state of West Bengal.

Out of two waste- water samples, one named as **'S-A'** was collected 1 to 2 Km apart from main temple area and other sample named as **'S-B'** was collected from the main temple area of the above mentioned place of Tarapith.

The samples were collected in plastic containers previously cleaned by washing in detergent, followed by rinsing with tap water and finally rinsed with deionized water. During sampling, sample bottles were rinsed with sample water and then filled up to the brim and stored in the refrigerator [9]. Within couple of week the samples were analyzed in SDET-Brainware Group of Institutions, Barasat campus, chemistry/environmental engineering laboratory.

5.2. DETERMINATION OF PARAMETERS

In the present analysis, different parameters e.g. temperature, pH, TSS, COD were determined. Temperature was determined using Celsius thermometer. pH was determined using pH meter(Systronics-335).COD was determined by using closed reflux method [8].

Chemical oxygen demand (COD):

Chemical oxygen demand is the amount of oxygen consumed by chemically oxidisable organic matte present in the water samples[10]. It is an important variable for characterizing any type of water bodies [1].

COD mg/lit =

Where,

A = volume (ml) of ferrous ammonium sulphate for blank

B = volume (ml) of ferrous ammonium sulphate for sample

N = normality of ferrous ammonium sulphate

V = volume of sample taken

Total suspended solid (TSS):

100 ml of each waste water sample was filtered through pre weighted filter paper (Whatman2).Then the paper was dried at 102-105 ^{0}C in hot air woven. Then was cooled in room temperature and weight was taken. From the difference of weight TSS was determined.

5.3. DETERMINATION OF DO AND BOD

Both the samples S-A and S-B were diluted 150 times and diluted samples S-A and S-Bindividually were transferred to 18 numbers of BOD bottles. Three bottles for each sample were analyzed for Do on the initial day and rest bottles were kept in BOD incubator at 20^{o}C after adding nutrients and phosphate buffer (to maintain the pH at 5.8 ± 0.2).On each subsequent day three bottles corresponding to each sample were tested for DO. This was run for five consecutive days. By subtracting initial DO value from the DO value of a particular day and multiplying by the dilution factor BOD1 to BOD5 were determined. The Winkler azide modification was used for the determination of the DO[9].

Table1. Average BOD Value(mg/lit) For 'S-A' And 'S-B'

Sample	BOD_1	BOD_2	BOD_3	BOD_4	BOD_5
S-A	120	160	232	272	336
S-B	96	224	280	344	416

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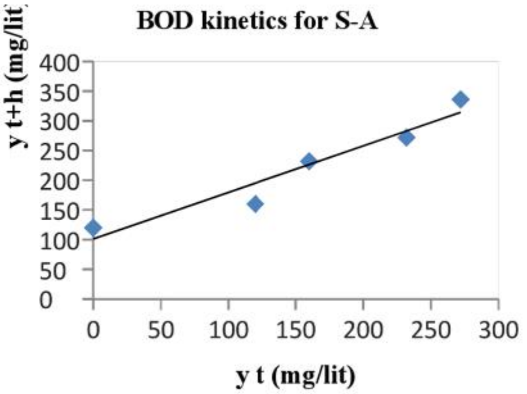
To solve BOD rate constant (K) and ultimate BOD (L) equation (3) was considered. $y_t$and y_{t+h}werealso calculated from the same.

Table2. y_{t+h} and $y_t$for 'S-A'

Sample	y_t(mg/lit)	y_{t+h} (mg/lit)
S-A	0	120
	120	160
	160	232
	232	272
	272	336

Fig.1. Variation of y_{t+h} with$y_t$for 'S-A'



From the **fig.1** we have

Slope = e^{-kh} = 0.7844 and hence **K = 0.2428 day^{-1}**

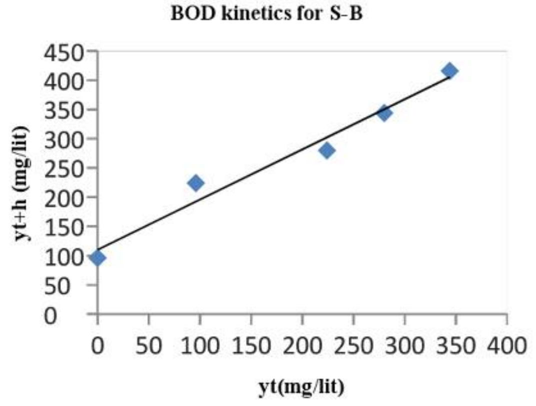
Intercept = L [1- e^{-kh}] = 101.01 and hence

L =468.506 mg/lit (h = 1)

Table3. y_{t+h} and$y_t$for 'S-B'

Sample	y_t(mg/lit)	y_{t+h} (mg/lit)
S-B	0	96
	96	224
	224	280
	280	344
	344	416

Fig.2. Variation of y_{t+h} with$y_t$for 'S-B'



From the **fig.2.**we have

Slope = e^{-kh} = 0.8505 and hence **K = 0.1525 day^{-1}**

Intercept = L [1- e^{-kh}] = 109.91 and hence

L =776.74 mg/lit (h =1)

Table4. Comparative study of K_1 and L for S-A and S-B

Sample	K_1 (day^{-1})	L(mg/lit)
S-A	0.2428	468.506
S-B	0.1525	776.74

6. RESULTS AND DISCUSSIONS:

6.1 TEMPERATURE

Temperature of both S-A and S-B were noted at 30.2±2 after sample collection.

6.2 pH

pH of S-A was noted at 4.43 and of S-B was noted at 4.88, which are much lower than the limits (5.5-9.0) set by Indian Standards. It may be due to the decomposition of food ingredients that form acid.

6.3 BOD & COD

The biological oxygen demand for five days at 20ºC (BOD_5) and chemical oxygen demand (COD) levels were normal[5].

6.4 TSS

Amount of total suspended solid (TSS) for both S-A and S-B were not within the limits (100 mg/lit) set by Indian Standards.

6.5 BOD reaction rate constant(K_1)

Our result for K_1 **(Table4)** was found to be closer to that reported by F.M. Abdelrasoul et al., 1996[5]

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Table5. Physicochemical parameters for S-A and S-B done by us

Sample	pH	TSS mg/lit	BOD5 mg/lit	COD mg/lit
S-A	4.4	370	336	688.45
S-B	4.8	150	416	966

Table6. Physicochemical parameters for Rakta and Sewage Sample done by F.M. Abdelrasoul 1996[5]

Sample	pH	TSS mg/lit	BOD5 mg/lit	COD mg/lit
Rakta	8.1	825	487.2	1200
Sewage	7.4	243	174.5	400

8. Conclusions:

- The rate constant K_1 of the BOD reaction for the two municipal waste water samples were determined for a 20^0C .
- It is seen that the waste water samples S-A having lower value of ultimate BOD value has higher rate of reaction whereas the sample S-B having higher value of ultimate BOD has reaction rate lower. This may due to the presence of some organic compounds in the sample S-B which are not easily biodegradable but ultimately degrades

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