COMPARATIVE ASSESSMENT OF THE BIODEGRADABILITY OF SEWAGE, ABATTOIR WASTEWATER AND CASSAVA WASTEWATER

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ABSTRACT

Sewage, cassava wastewater and abattoir wastewater were subjected to different temperatures for a period of six days and analyzed for BOD on a daily basis. Results obtained show that cassava and abattoir wastewater need even more severe treatment than sewage before disposal. BOD constant k'_1 for sewage at 15^0C was found to be less than those of cassava and abattoir wastewater at the same temperature. However, above 15^0C, k'_1 for sewage was found to be more than those for cassava and abattoir wastewaters. The values k'_1 for cassava and abattoir wastewaters were found to be close (between 0.397 day^{-1} and 0.44 day^{-1}) for all temperatures investigated. Arrhenius constant was found to be 1.194, 1.002 and 1.004 for sewage, cassava wastewater and abattoir wastewater respectively. The study also shows that the conventional 5-day BOD at 20^0C is probably being overrelied on as cassava wastewater and abattoir wastewater were found to attain maximum BOD_5 removal at 27^0C.

INTRODUCTION

The developed world may have succeeded at proper management of toxic waste from complicated industrial processes, but many developing nations still battle with such basic issues as treatment and disposal of sewage and other wastes from domestic activities or cottage industries. In rural and semi-urban areas all over Africa and Nigeria in particular, wastewaters are allowed to flow from homes and small food processing plants directly into streams and rivers. Unfortunately, people still rely on these streams for potable water.

Cassava wastewater is usually a by-product of the production of *garri*, starch, tapioca, cassava flour, etc. Many village dwellers ferment and wash cassava in their streams[1] without being aware of the harm they might be doing to people who fetch the water a few meters downstream. Table 1[2] shows the heavy bioload of cassava wastewater from starch production. It has been reported that in the region of the Cauca Valley (Colombia), wastewaters generated from the starch extraction process by about 250 existing small-scale plants are directly discharged into rivers without any treatment[3] . There is no doubt that this observation rings familiar to anyone who has been to a rural area.

Although it has been reported that fermentation reduces the cyanide content of cassava, a significant reduction is only achieved if the soaking water is routinely changed[4] . Unfortunately the practice of routine change of soaking water is hardly done partly due to ignorance and partly due to water scarcity in some areas. Cassava wastewater can be put to use by holding it in a tank to allow organic matter and suspended solids to settle and thereafter used for irrigation[5]. Treatment of cassava wastewater need not involve an imported complex technology beyond the reach of the individual. Researchers have shown that cassava wastewater can be treated using a filter bedpacked with bamboo which is a locally available material[1].

Cassava wastewater is of foremost significance in this research because many people have died after meals prepared from cassava.

Table 1

Main characteristics of the cassava starch extraction wastewater

Parameter[a]	Range	Average value[b]
pH	3.6–6.5	5.3 ± 0.7
Chemical demand for oxygen, COD	4200–7000	4800 ± 810
Soluble COD, SCOD	3500–6100	3850 ± 740
Biochemical demand for oxygen, BOD	1100–3900	1680 ± 755
Total solids, TS	2300–6600	3800 ± 1305
Total suspended solids, TSS	700–2200	1350 ± 440
Volatile suspended solids, VSS	600–2050	1200 ± 560
Total carbohydrates	330–400	365 ± 19
Lactic acid	1200–2000	1400 ± 240
Acetic acid	330–400	350 ± 19
Total nitrogen	80–150	105 ± 16
Total phosphorus	20–35	25.1 ± 8.1
Cyanide	3–5	3.5 ± 0.5
Water used/ton of cassava proceeded (m^3)	10–14	11 ± 1.1

[a] All parameters except pH are in mg/L.
[b] Average value was taken from 12 starch extraction plants. All analyses were carried out with three replicates.
[c] Results were means of 26 analyses with three replicates.

Abattoir wastewater is another wastewater that is usually discharged into the environment without any treatment. Wastewater from most slaughter houses in the country are conveyed by drains to the nearest roadside channel from where they flow to streams and rivers, thereby leading to high organic load in the affected water bodies. This practice has contributed further to the degrading and fouling of the natural environment. Abattoir wastewater has a complex composition and is very harmful to the environment[6]. Previous researches have shown that untreated abattoir wastewater can cause severe deoxygenation of streams and groundwater contamination[7,8].

METHODOLOGY

Sewage was collected from the inlet of the University of Nigeria, Nsukka waste stabilization pond. Abattoir wastewater was collected from Ogige Abbatoir in Nsukka, Enugu State, Nigeria. Cassava wastewater was collected from a garri processing firm along Ochumba Street, Achara Layout, Enugu. The wastewaters were characterized and then incubated for BOD at different temperatures as follows: 15^0C, 27^0C and 35^0C for six days. The samples were tested for BOD everyday for the six days. It should be noted that fresh samples of the three categories of wastewater were collected for each temperature. The same sample should have been used for each category were it not for frequent power outage which made preservation of samples very difficult. Moreover, there were not enough incubators to run the experiments concurrently.

The values of k' were obtained for the different wastewaters at different temperatures using Thomas method. Thomas[9] using common logarithms, transformed the BOD equation into a linear form as follows:

$$\left(\frac{t}{BOD_t}\right)^{1/3} = \left(2.3k_1^{'}L_0\right)^{-1/3} + \left(\frac{k_1^{'2/3}}{3.43L_0^{1/3}}\right)t \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where BOD_t = Biochemical oxygen demand required by micro-organisms at any time t, L_o = ultimate BOD, k'_1 = BOD rate constant.

Equation (1) is a straight line of the form $y = a + bx$

If $\left(\frac{t}{BOD_t}\right)^{1/3}$ is regressed or plotted against t, the slope (*b*) will be equal to $\left(\frac{k_1^{'2/3}}{3.43L_0^{1/3}}\right)$ while the intercept (*a*) will be equal to $\left(2.3k_1^{'}L_0\right)^{-1/3}$. Hence $k_1^{'} = 2.61(b/a)$ *and* $L_0 = \left(2.3k_1^{'}a^3\right)^{-}$ (see Figs. 2-4). The values of k'_1 obtained for each type of wastewater at different temperatures were used to obtain the Arrhenius constants for cassava wastewater, abattoir wastewater and sewage. In order to obtain Arrhenius constant for each wastewater, Arrhenius equation was transformed as follows:

$$Logk_T = Logk_0 + (T - T_0)Log\theta \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where k_T = BOD rate constant at T ^{0}C, k_0 = BOD rate constant at base temperature usually 20 ^{0}C, θ = Arrhenius constant, T_0 = 20 ^{0}C for wastewater.

Hence, equation (2) can be rewritten thus:

$$Logk_T = Logk_{20} + (T - 20)Log\theta \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$Logk_T$ was plotted (regressed) against $(T - 20)$ so that the slope yields $Log\theta$ while the intercept yields $Logk_{20}$.

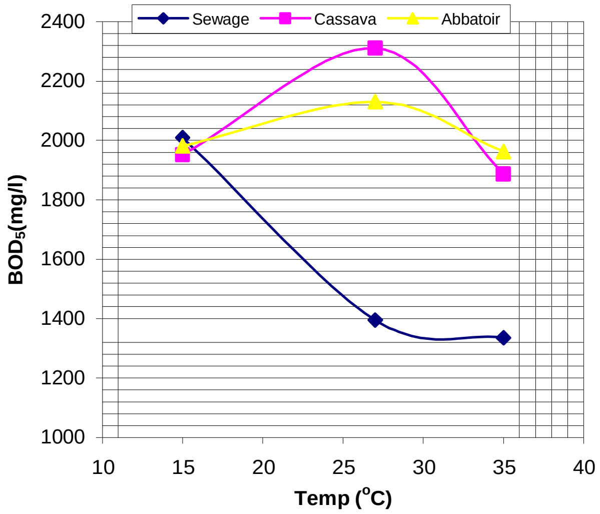

Fig 1: BOD_5 versus Temperature

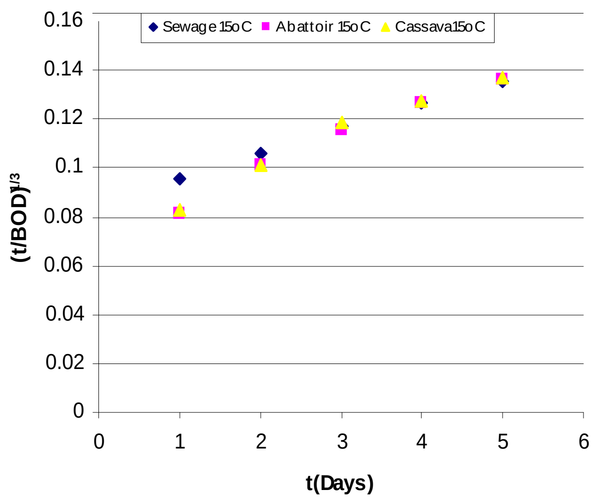

Fig 2: $(t/BOD_5)1/3$ versus Time for 15^{o}C

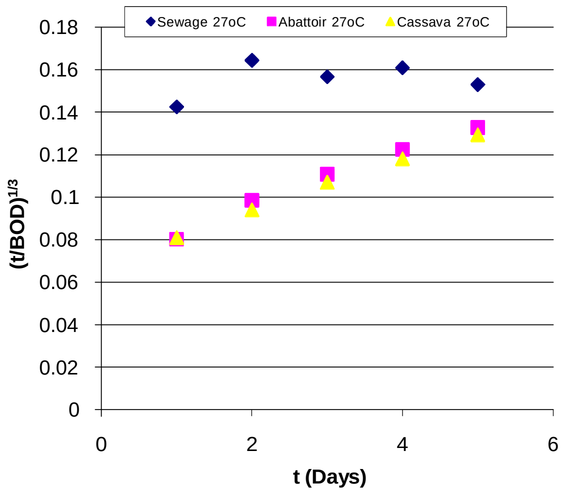

Fig 3: $(t/BOD_5)1/3$ versus Time for 27^oC

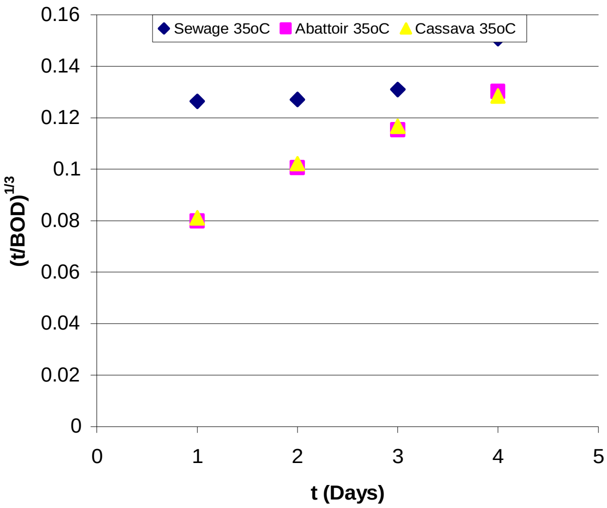

Fig 4: $(t/BOD_5)1/3$ versus Time for 35^oC

RESULTS AND DISCUSSION

Preliminary results obtained show that cassava wastewater is richer in COD than the other two, while abattoir wastewater has more suspended solids than others. Figures 6-9 show that at lower temperatures (about 15^0C), k'_1 values for the three wastewaters were close while at higher temperatures (about 35^0C), the k'_1 values for sewage increases exponentially. Also, at lower temperatures, the *k* values for sewage were lower for both cassava and abattoir wastewater. At 15^0C precisely, the k'_1 value for sewage (0.27 day^{-1}) was found to be about half the values of cassava and abattoir wastewater with k'_1 values of 0.42 day^{-1} and 0.44 day^{-1} respectively at the same temperature. Furthermore, the k'_1 values for cassava and abattoir wastewater remained fairly constant with change in temperature.

This observation suggests that the biodegradation of cassava and abattoir wastewater were affected by temperature to a much less degree than it affected that of sewage, though Figure 2 (a plot of BOD_5 versus temperature) shows that for cassava wastewater and abattoir wastewater, the optimum temperature for the biodegradation was 27^0C. The BOD test was first used in the late 1800s by the Royal Commission on Sewage Disposal as a measure of the amount of organic pollution in British rivers[10]. At that time, the test was standardized to run for 5 days at 18.3"C.

These numbers were chosen because none of the British rivers had headwater-to-sea travel times greater than 5 days, and the average summer temperature for the rivers was 18.3"C. Accordingly, this should reveal the "worst case" oxygen demand in any British river. The BOD incubation temperature was later rounded to 20"C, but the 5-day test period remains the current, if somewhat arbitrary, standard. So it can now be seen that, while 5-day BOD at 20^0C may give a good approximation of the organic load of sewage, for abattoir and cassava wastewater, 5-day BOD at about 27^0C will give a better estimation. Higher temperature could kill off active micro-organisms while lower temperatures could immobilize them. Bacteria in sewage are more sensitive to temperature because sewage is a milder waste than abattoir wastewater and more especially cassava wastewater. Hence sewage can sustain a wider range of micro-organisms than cassava wastewater and abattoir wastewater.

Arrhenius constant was obtained for the three categories of wastewater (see Fig. 5 and table 3). The Arrhenius constant obtained for sewage, cassava wastewater and abattoir wastewater are 1.194, 1.002 and 1.004 respectively. Hence, Arrhenius equation can be written thus:

For sewage, $k_{20} = k_T (1.194)^{T-20}$ … … … … … (4)

For cassava wastewater, $k_{20} = k_T (1.002)^{T-20}$ … … … (5)

For abattoir wastewater, $k_{20} = k_T (1.004)^{T-20}$ … … … (6)

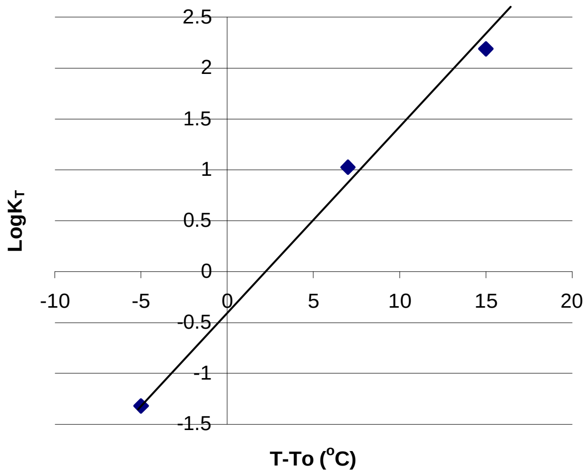

Fig 5: Log K_T versus T-T_0 for Determination of Arrhenius Constant for Sewage

Table 2: Arrhenius Constants for Different Wastewater

	Arrhenius Constant
Sewage	**1.194**
Cassava	**1.002**
Abbatoir	**1.004**

The constants were then substituted into the Arrhenius equation and the resulting equations were used to predict the k'_1 values. It was also observed that the predicted value of k'_1 using Arrhenius equation agreed well with the observed values for sewage, but not so well for cassava wastewater and abattoir wastewater (see Figs. 6 to 9 and Table 3).

Table 3: Calculated and Observed Values of K

Wastewater	K	15°C	27°C	35°C
Sewage	$K_{calculated}$	0.289144	2.331728	9.376775
	$K_{observed}$	0.266784	2.78921	8.93303
Abattoir	$K_{calculated}$	0.429344	0.450412	0.465029
	$K_{observed}$	0.440426	0.42295	0.487419
Cassava	$K_{calculated}$	0.409885	0.419831	0.426595
	$K_{observed}$	0.420036	0.397135	0.441604

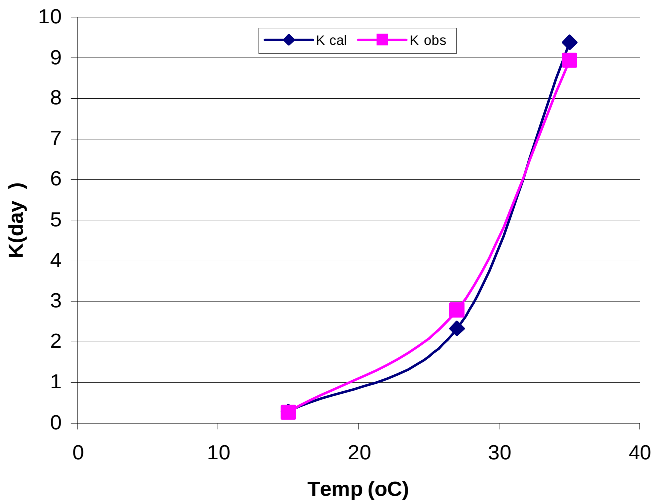

Fig 6: Calculated and Observed Values of K for Sewage

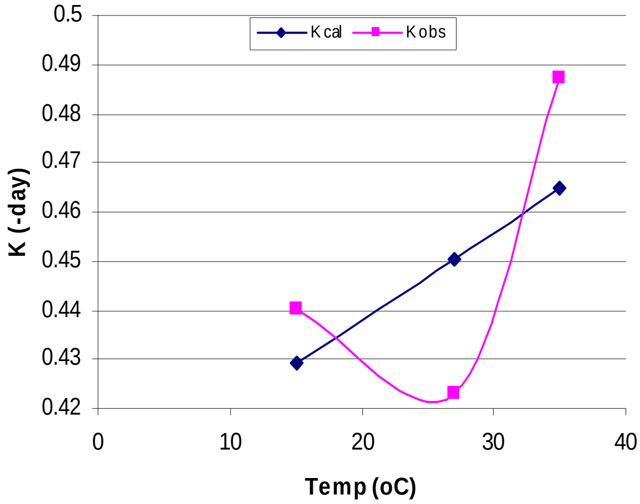

Fig 7: Calculated and Observed Values of K for Abattoir

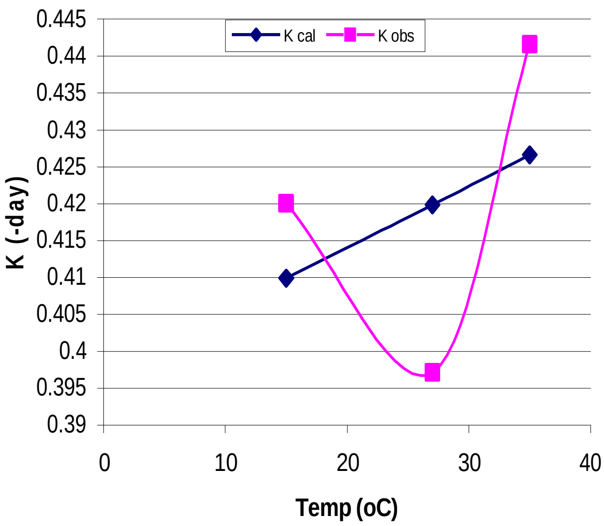

Fig 8: Calculated and Observed Values of K for Abattoir

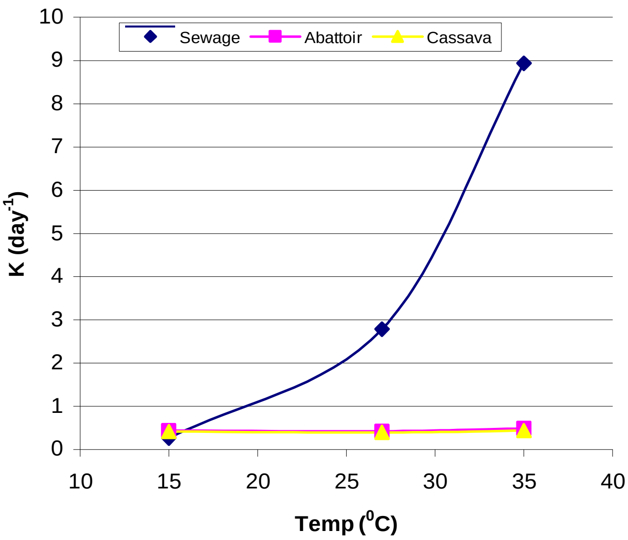

Fig 9: Comparison of *k* values for sewage abattoir and cassava

CONCLUSION

It can be clearly seen from this study, that the value of k'_1 is not the same for all kinds of wastewater. Obviously, activities of bacteria in cassava wastewater are usually inhibited by the presence of cyanide which will, in turn, affect the *k* value. It is therefore pertinent to employ the appropriate k'_1 values in the design of treatment plants for different categories of wastewater. It can also be inferred that sewage is easier to treat and degrades faster than abattoir wastewater and cassava wastewater.

RECOMMENDATION

Cassava wastewater and abattoir wastewater must be given a substantial level of treatment before being discharged into the environment.

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