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TREATMENT OF BUTANOL AND PROPANOL CONTAINING WASTEWATER

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ABSTRACT

In this article an synthetic wastewater samples containing different concentrations of butanol and propanol were subjected to biological treatment utilizing microorganisms from a domestic sewage. Butanol concentrations ranged from 22- 457 mg/l and the concentrations of propanol ranged from 68-457 mg/l. Measurements of biochemical oxygen demand (BOD) over a long period (30 days) showed that biological treatment of butanol and propanol is feasible within certain concentrations. The threshold in case of butanol is about 68 mg/l, a lag period of 6-10 days was observed with higher concentrations and complete toxicity occurred for concentrations exceeding 228 mg/l. Propanol, concentrations between 68 and 228 mg/l were found biodegradable but the BOD values decreased for concentration 343 and 457 mg/l, indicating increased toxicity with increasing concentration above 228 mg/l.

Key Words : *Biological treatment; biochemical oxygen demand (BOD); microorganisms; wastewater treatment; butanol; propanol.*

INTRODUCTION

In aerobic biological treatment of wastewater, organic matter is removed from solution by biological metabolism, oxygen is consumed by the microorganisms and new cell mass is grown. When a wastewater is mixed with acclimated biological sludge, there may be an immediate sorption of readily degradable organics. The organics are stored within the cell for subsequent oxidation. This phenomenon is called bio-sorption. As aeration proceeds, removal of the remaining organics occurs. The oxygen uptake rate is initially high as the sorbed organics are degraded and then decreases as the residual substrate decreases. Rate of cellular proliferaion occurs in proportion to the rate of organic removal. When the available substrate is exhausted, continued aeration results in oxidation of the biomass through endogenous respiration.

Microorganisms + Organic Matter + Oxygen → More Biomass + CO_2 + H_2O + Residual organic matter (Madigan and Martincnko, 2006).

A variety of microorganisms are used to degrade hydrocarbons in order to minimize contamination caused by several industrial activities (Lotfy et. al. 2002; Gotvajn et. al, 2003; Lotfy 2004, 2005, 2007). Because wastewater treatment operations occupy much space, they are located outdoor, and this implies that the system must be able to operate at seasonally varying temperatures. The microbial population consists of a variety of microorgan-

isms, and accommodation to a temperature change is accomplished by self adaptation of the cell population. Similarly, a change in composition of the organic material (due to people's changing activities) leads to a spontaneous change in the microbial population, with the microorganisms best suited to digest the new material growing in larger numbers than others. Biological treatment processes are economical and efficient methods that can be used for treating wastewater from oil and other industries (Izanloo et. al., 2007). Propanol and butanol were found in the wastewater of different industries, including dairy industries (Yu H. and Fang H., 2001). This study investigates the removal of butanol and propanol from wastewater samples utilizing a biological treatment technique.

Microorganisms are only able to remove biodegradable chemicals from the water. One of the most indicative water quality control parameters is the Biochemical Oxygen Demand (BOD) test. BOD is the amount of oxygen required by bacteria while oxidizing decomposable organic matter under aerobic conditions. It measures the oxygen utilized during a specific incubation period for the biochemical degradation of organic materials. An experimental procedure which gained popularity is the manometric technique which monitor the progression of biodegradation reactions through measuring the oxygen uptake by microorganisms while decomposing biodegradable organic matter.

MATERIALS AND METHODS

Reagents and chemicals :

Butanol and propanol are commercially available, while solvents and other chemicals used were all reagent-grade.

Synthetic wastewater composition (minimal microbial growth medium): -

Composition of the Synthetic Wastewater is illustrated in Table (1).

Table 1 : Synthetic Wastewater Constituents.

Constituent	Stock concentration g/l	Quantity used ml/5 liter	Final concentration mg/l
Bacto-Peptone	32.25	27.3	352.73
$MgSO_4.7H_2O$	10.00	25.0	50.00
$MnSO_4.H_2O$	1.00	25.0	5.00
$FeCl_3.6H_2O$	0.175	25.0	1.00
$CaCl_2$	100.00	25.0	3.75
KH_2PO_4	52.25	33.4	349.4
K_2HPO_4	107.00	33.4	715.56

The BOD of the seed (municipal wastewater) alone was measured using the manometric technique (Standard Methods of Examination of Water and Wastewater, 1985), under the same experimental conditions in each run. Experiments were done in the dark (for optimal bacterial growth and to avoid decomposition by direct light) and with a magnetic stirring at 20°C. All bottles were dosed with 10% seed (municipal wastewater) to inoculate them with microorganisms and the experiments were done in duplicates. Microbial growth medium (Table 1) was adjusted to pH 6.8 (by adding drops of 1 N H_2SO_4 if the pH is high and drops of 1N NaOH if the pH is low). Butanol was added in concentrations 22, 45, 68, 91, 114, 228, 343, 457 mg/l. Propanol was added in concentrations 68, 91, 114, 228, 343, 457 mg/l. In all experiments, treatments and controls were done under the same experimental conditions. Seed corrected data were obtained by subtracting blank values from the corresponding values in other experiments, that gave BOD values corresponding to the chemical added "pure substrate" only.

RESULTS AND DISCUSSION

In butanol experiments seed corrected data were obtained. Results are shown in Figures.1, 2 and 3.

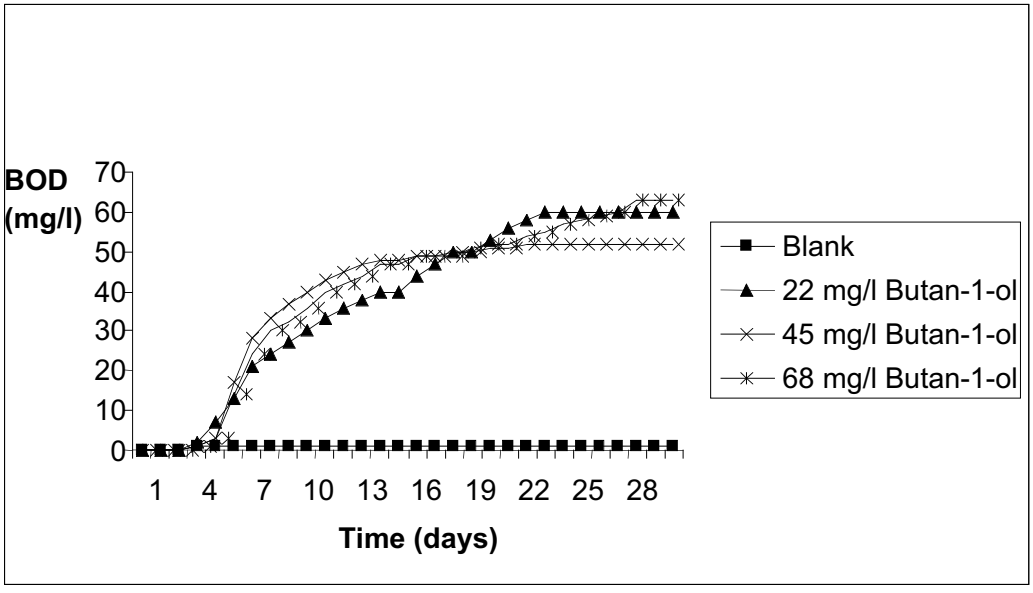

Fig. 1 : BOD for wastewater containing butanol at concentrations 22, 45 and 68 mg/l.

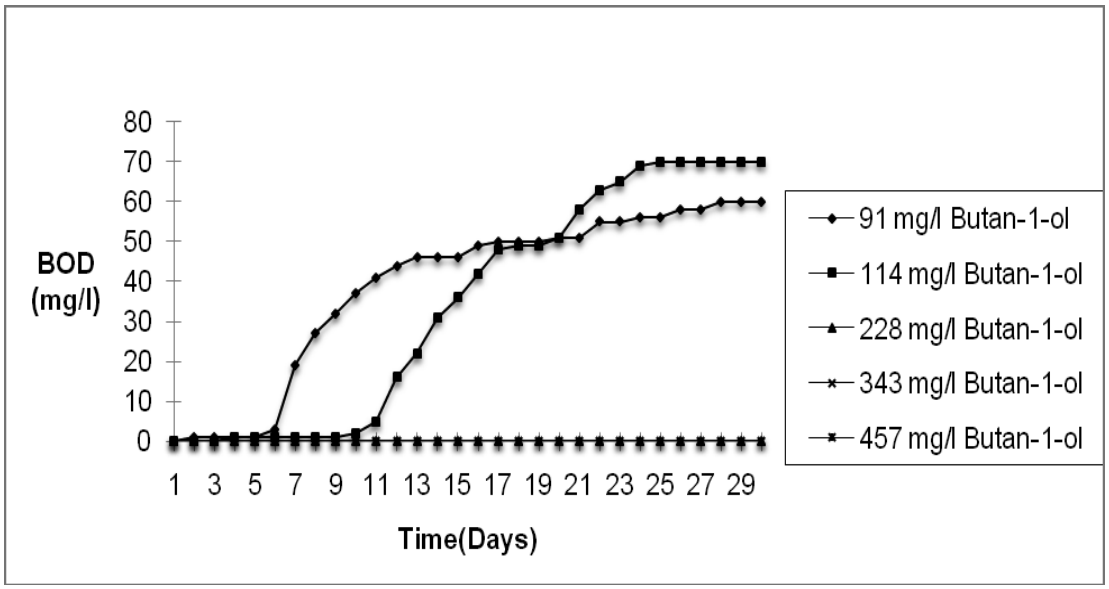

Fig. 2 : BOD for wastewater containing butanol at concentrations ranging from 91 to 457 mg/l.

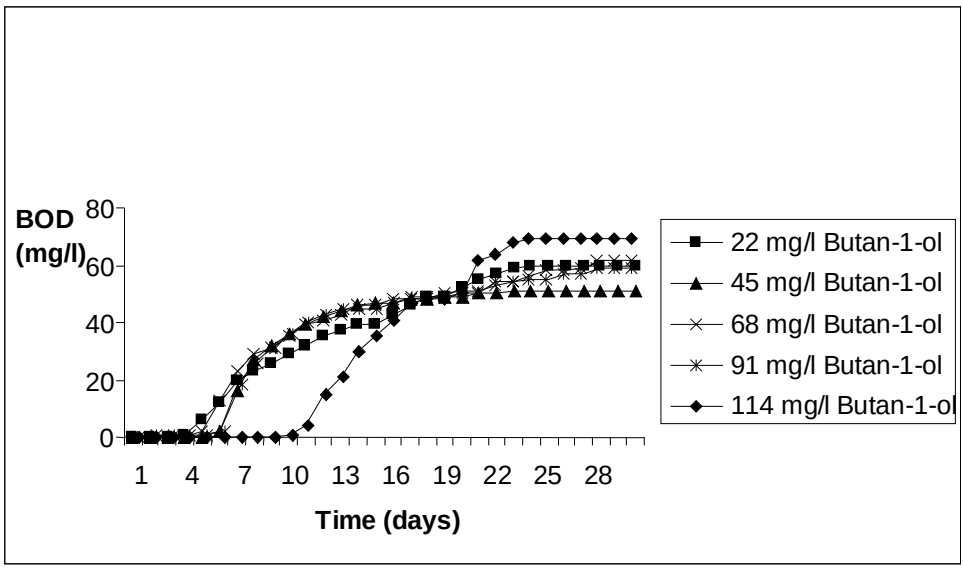

Fig. 3 : BOD as seed corrected data, concentrations from 22 to 114 mg/l butanol.

Butanol, in concentrations less than 68 mg/l, is being used as a nutrient and encouraged the growth of degrading microbes. It appears that 15 days are required to reach the plateau value which indicates the termination of the substrate.

Butanol at a concentration of 114 mg/l, delayed biological activity for 10 days, meaning that microorganisms were still adapting to the butanol. Complete inhibition occurred at concentrations higher than 228 mg/l (there was no oxygen consumption throughout the experimental period).

In propanol experiments seed corrected data were obtained. Results are shown in Figures.4, 5, 6 and 7.

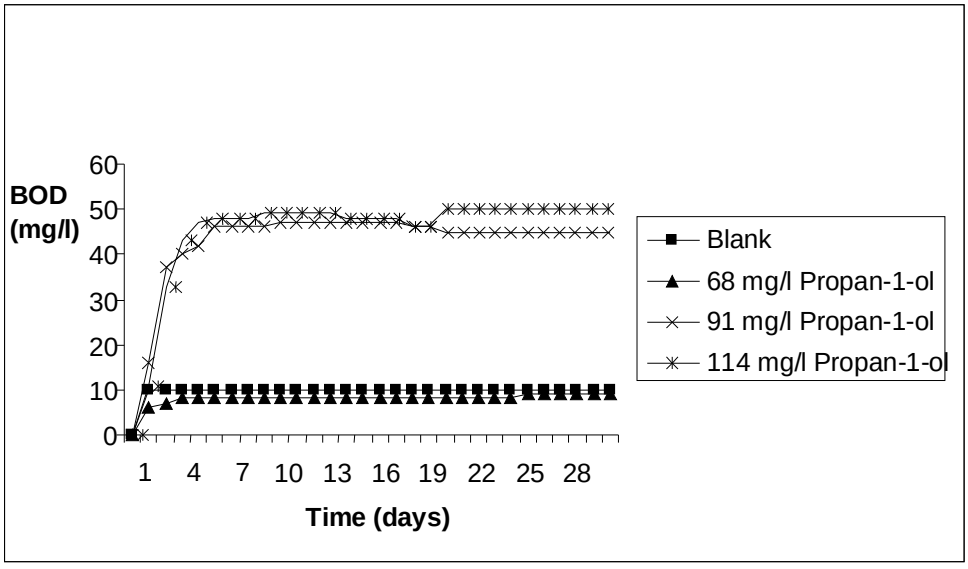

Fig. 4 : BOD in wastewater containing propanol at concentrations from 68 to 114 mg/l.

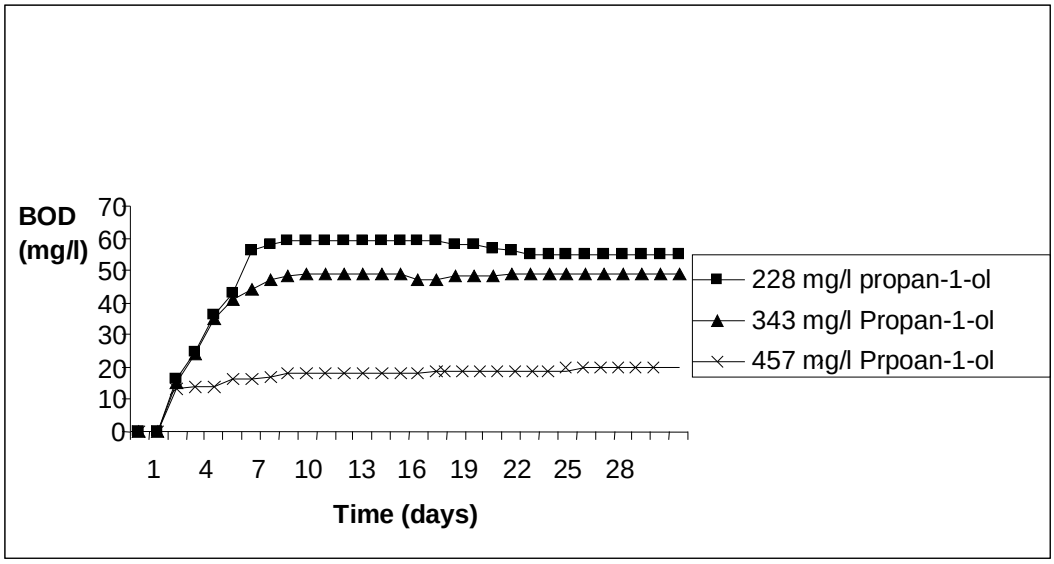

Fig. 5 : BOD in wastewater containing propanol at concentrations 228, 343 and 114 mg/l.

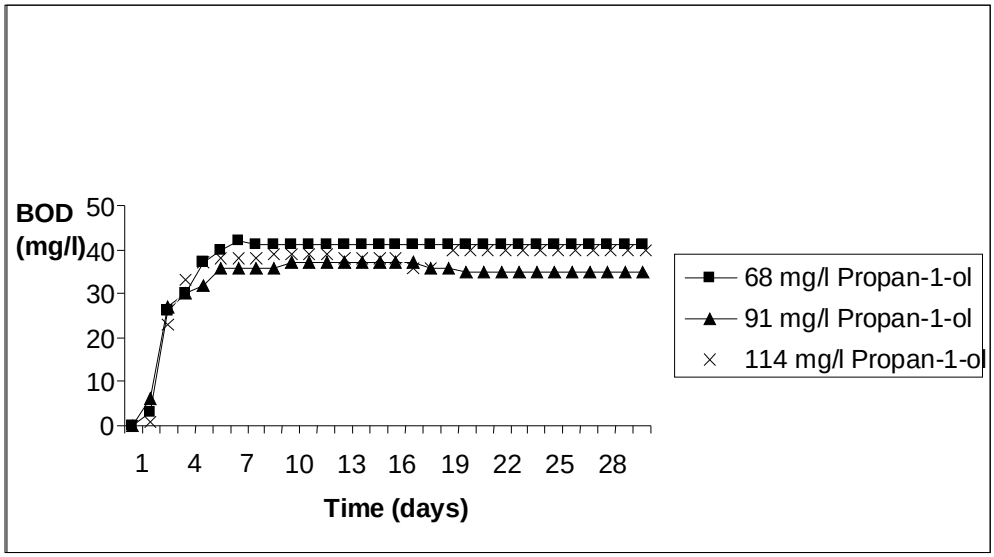

Fig. 6 : BOD as seed corrected data concentrations from 68 to 114 mg/l propanol.

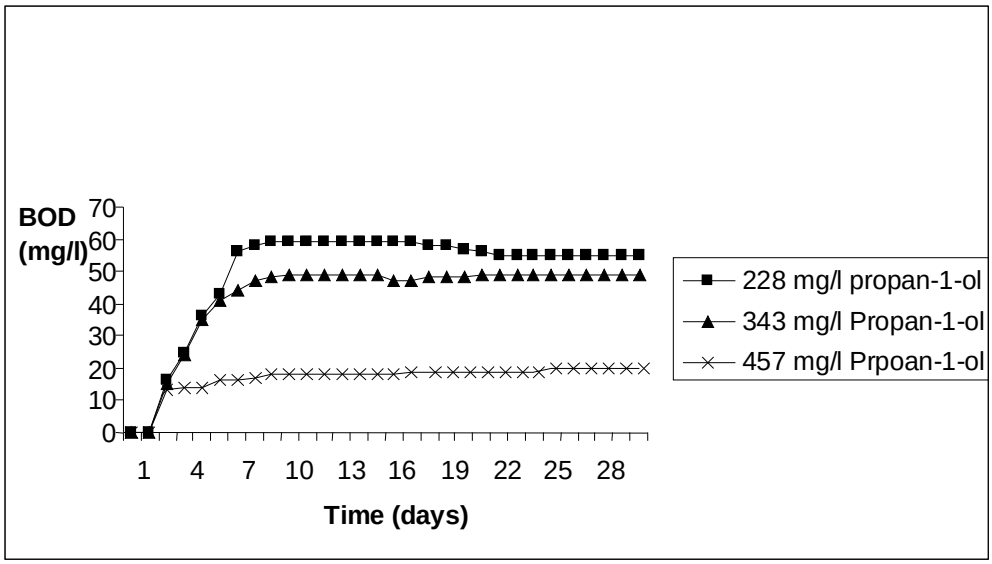

Fig. 7 : BOD as seed corrected data, concentrations from 228 to 457 mg/l propanol.

Propanol in concentrations around 228 mg/l is being used as a nutrient and encouraged the growth of degrading microbes as indicated by increased BOD values. It appears that 7 days are required to reach the plateau value which indicates the termination of the substrate.

Propanol at a concentration of 228 mg/l or more delayed the biological activity for 2 days meaning that microorganisms were still adapting to the propanol. A decrease in microbial activities occurred at 343 mg/l, reflecting increased toxicity.

CONCLUSIONS

In case of effluents containing butanol at concentrations around 68 mg/l, biological treatment seems to be a reasonable way of treatment. It appears that 15 days is a convenient time to reach satisfactory biodegradation.

In case of effluents containing propanol at concentrations around 228 mg/l, biological treatment seems to be a reasonable way of treatment. It appears that 7 days is a convenient time to reach satisfactory biodegradation.

Butanol at a concentration of 114 mg/l delayed the biological activity for 10 days. Complete inhibition occurred at concentrations higher than 228 mg/l.

Propanol at a concentration of 228 mg/l delayed the biological activity for 2 days, and microbial activities decreased for concentrations 343 and 457 mg/l indicating increased toxicity.

Biodegradation seems to be a successful technique to decrease or remove butanol and propanol from wastewater within certain concentrations.

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الملخص العربى

معالجة مياه صرف تحتوى على مـادتى البيوتانـول والبروبانـول

هشـام لطفى لـويـدا إنـدونجـو

قسم الكيمياء والكيمياء الحيوية - كلية العلـوم - جامعـة نامبيا - وندهويك - نامبيا

تناول هذا البحث المعالجة البيولوچية لمياه صرف تحتوى على مادتى البيوتانول والبروبانول وهما يدخلان فى العديد من الصناعات ممايتتج عنه تواجدهما فى مياه الصرف الصناعى وإمكانية تسربهما للمسطحات المائية، تناول البحث دراسة المعالجة البيولوچية لمياه صرف تحتوى على مادة البيوتانول بتركيزات تتراوح بين ٢٢ - ٤٥٧ ملجم / لتر ومادة البروبانول بتركيزات تتراوح بين ٦٨ - ٤٥٧ ملجم / لتر، وبقياس الأكسجيز الحيوى الممتص لمدة زمنية زادت عن الثلاثين يوماً لكل تركيز تبين أن التركيز الأقصى الذى يمكم معالجته بيولوچياً فى حالة البيوتانول هو ٦٨ ملجم / لتر، أما فى حالة مادة البروبانول فقد وجد أن التركيزات حتى ٢٢٨ملجم / لتر يمكن هضمها بكتيريا وزادت السمية تدريجياً مع زيادة التركيز عن ٢٢٨ ملجم / لتر، وجد أيضاً أن المدة الزمنية اللازمة للمعالجة البيولوچية لمياة صرف تحوى على البيوتانول هى ١٥ يوماً تقريباً والمدة الزمنية اللازمة لمعالجة مياه صرف تحتوى على مادة البروبانول هى ٧ أيام تقريباً، تؤكد النتائج السابقة على إمكانية المعالجة البيولوچية لمياه الصرف الصناعى المحتوى على عنصرى البيوتانول والبروبانول فى حدود التركيزات السابقة (فى حالة البيوتانول هو ٦٨ ملجم / لتر، أما فى حالة مادة البروبانول حتى ٢٢٨ ملجم / لتر) مع الأخذ بالمدة الزمنية اللازمة لكل معالجة.

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