Central Asian Journal of Environmental Science and Technology Innovation **1**(5): 277-280 (2020)

RESEARCH PAPER

# Co-treatment of chlorophenol and methanolic wastes

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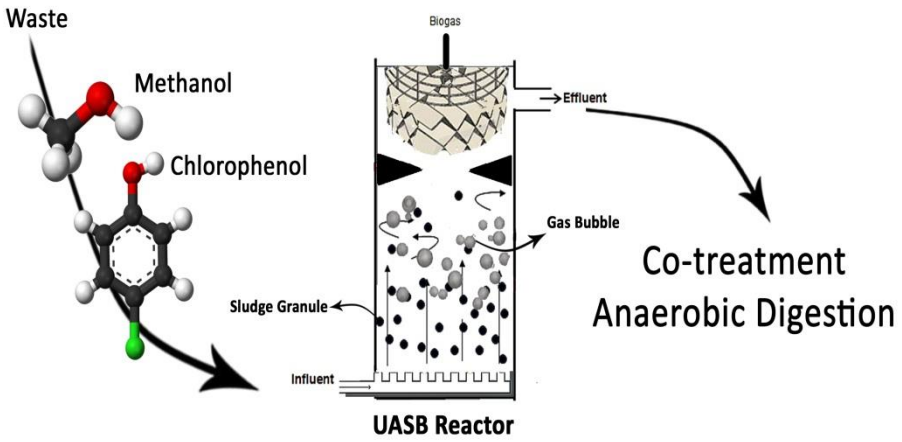
## Highlights

- The treatability of CP-M wastes in a single-step UASB reactor is quite feasible.
- The biogas production rate was comparatively less in such cases, but the kinetic coefficient was identical.
- The anaerobic digestion of CP-M is a useful and promising technique.

## Graphical Abstract




## Article Info

**Receive Date:** 05 August 2020
**Revise Date:** 20 September 2020
**Accept Date:** 13 October 2020
**Available online:** 18 October 2020

**Keywords:**
Anaerobic digestion
UASB
Chlorophenol
Methanolic wastes

## Abstract

Treatment feasibility of Cholorphenol and methanolic waste (CP-M) was examined in an experimental UASB reactor for 40-42 weeks. Permissible organic loading rate (OLR) to achieve 80% TOC was observed to be 6.25g-TOC/L-d with 18mg-CP/L, at a hydraulic retention time (HRT) of 12-48 h. The overall gas conversation rate observed at greater than 80% TOC removal efficiency was found to be 0.13L/g-CODrem with 60% of methane content. Kinetic coefficients of k, Ks, Y and kd were determined to be 0.70g-TOC/g-VSS.d, 0.30g-TOC/L, 0.26g-VSS/g-TOC and 0.02day-1, respectively. The results of this study suggested that the anaerobic digestion of CP-M is a promising technique.

10.22034/CAJESTI.2020.05.04

E-ISSN: 2717-0519
P-ISSN: 2717-4034

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## 1. Introduction

The industrial wastewater treatment is a challenging issue, especially for the developing nations. The methanolic wastes along with chlorophenol (CP-M), releases from a various industrial processes (Mtethiwa et al., 2008). For example, the bleaching process in paper mill produces enormous amount of such wastes (Bajpai, 2000; Yan and Allen, 1994). This waste is highly toxic being carcinogenic in nature. The literature survey illustrate that the anaerobic digestion is comparatively a viable options for the treatment of industrial effluent (Lettinga et al., 1984; Kallas and Munter, 1994; Ali and Sreekrishnan, 2001; Schellinkhout, 1993; Wiegant, 2001). Though, various attempts have been made to biodegrade the CP-M wastes as anaerobic, but still certain doubt persists in the previous studies (Savant et al., 2006), therefore, this study was particularly designed to investigate the anaerobic treatment performance for methanolic waste containing chlorophenol in a single-stage UASB reactor (Hall et al., 1995; Henze and Harremoës, 1983; Mahadevaswamy et al., 2004).

## 2. Materials and Methods

UASB reactor of 7.84 L capacity was used. For substrate, methanol and 2-Cholorphenol (CP), diluted with tap water to the desired concentration, were used as the carbon source in the feed (influent) (Rajakumar and Meenambal, 2008). Nitrogen and phosphorous were added, to ensure the C:N:P ratio of 350:5:1. Other required nutrients were also added, and the reactor was started-up in accordance to the available guidelines (Bhatti et al., 1996; Arshad et al., 2011). Gas was collected over a tap water saturated with NaCl. All analysis was carried out according to the Standard Methods (Yoochatchaval et al., 2008).

## 3. Results and Discussion

During the entire study pH of the reactor was maintained near neutral by adding an external buffer in the form of 0.03 M $NaHCO_3$ to the feed solution. Since, anaerobic bacteria are very much sensitive to alteration in temperature; therefore, the temp was kept constant 32±2 °C (Tezel et al., 2001; Kennedy andVan den Berg, 1982; Scholz-Muramatsu et al., 1995). In order to avoid sudden organic shocks to the reactor, the OLR was gradually increased from 0.2g-TOC/L-d to 32.0g-TOC/L-d, and the HRT was slowly decreased to 6hrs.

As shown in the Fig. 1, at low organic loading rates, i.e. ≤1.8g-TOC/L-d with 9.6mg-CP/L, the effect of HRT on the treatability performance was not prominent (Ferguson and Dalentoft, 1991). But at higher level, the effect of HRT was observed to be quite visible. For instance, at an OLR of 10.5g-TOC/L-d, the TOC/CP removal efficiency was decreased by 12-14%, when the HRT was changed from 36 hrs to 6hrs. It was also observed that the presence of CP in methanolic wastes can affect the treatability performance of the UASB reactor to a greater extent. This study demonstrates that workable OLR at practical HRT of 20-22 h, to achieve 80% TOC/CP removal efficiency for CP-M wastes using UASB reactor, is about 6.25g-TOC/L-d, containing 18mg-CP/L.

The average biogas production was observed to be 0.13L/g-$COD_{rem}$, with 60-62% methane contents. Though, the observed value is less than the theoretical of 0.35L/g-COD reduced (at STP), but this may be due to the presence of certain recalcitrant material in the reactor (Arshad and Hashim, 2012). Using Monod's equation, (reference), the kinetic constant, i.e. Y, $k_d$, k, and $K_s$ were determined to be 0.26g-VSS/g-TOC, 0.02$d^{-1}$, 0.70g-TOC/g-VSS-d, and 0.30g-TOC/L respectively, from the experimental data obtained (Fig. 2).

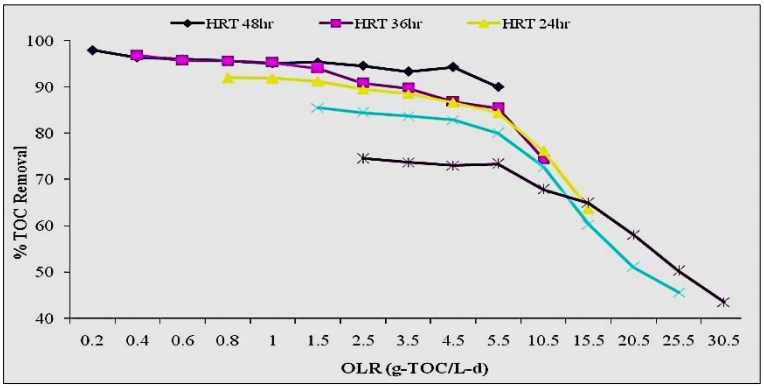


**Fig. 1.** TOC removal efficiency at varying OLR/HRT.

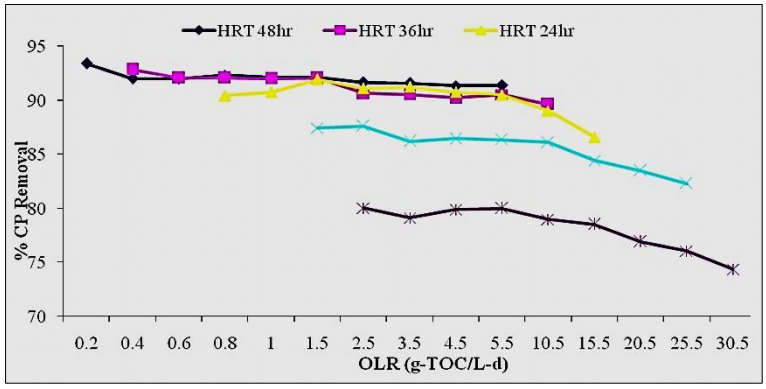


**Fig. 2.** Chlorophenol removal efficiency at varying OLR/HRT.

## 4. Conclusion

Applicable OLR to achieve 80% TOC/CP is 6.25g-TOC/L-d, with less than 18mg-CP/L. However, to achieve 70% TOC/CP removal efficiency at an OLR of 8.50g-TOC/L-d, the concentration of CP in the influent should not exceed beyond 24mg/L. The biogas production rate is comparatively less in such cases, whereas, the kinetic coefficients are quite identical to the work done on similar substrates. Though, as a whole the treatability of CP-M wastes in a single-step UASB reactor is quite feasible, but further detail investigation are required to study the impacts of recalcitrant material present in the substrate on the treatment efficiency of the reactor, if any.

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**How to cite this paper:**

Ali, A., Iqbal, M.M., Waheed, A., Tabinda., 2020. Co-treatment of chlorophenol and methanolic wastes. *Cent. Asian J. Environ. Sci. Technol. Innov.*, **1**(5): 277-280.