Effects of retting pond wastewater pollution and seasonal variation

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Abstract: This study focuses on the seasonal variation of physicochemical parameters of coconut husk retting wastewater samples. The main objective of this study is to assess the quality of wastewater during a period of 12 months. The physicochemical parameters such as pH, chemical oxygen demand (COD), biological oxygen demand (BOD), phenol concentration, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), colour and biodegradability of the wastewater samples were analysed. Most of the analysed parameters were found to be higher than the permissible limit of World Health Organisation (WHO) and Bureau of Indian Standards (BIS) water quality guidelines.

Keywords: retting pond wastewater; phenol; chemical oxygen demand; COD; biological oxygen demand; BOD; total suspended solids; TSS; total dissolved solids; TDS.

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1 Introduction

Freshwater is essential for human life and its quality has been a matter of global concern. Freshwater resources have been the solution for nearly all drinking and irrigation water demands (Abdel-Satar et al., 2016). Wastewater containing high concentrations of microbiological contaminants cause reduction in overall crop yield and quality in addition to the contamination of crops by pathogens and intestinal helminths. However, high yield can be achieved using pre-treated wastewater for irrigation purpose of various crops which in turn it supplies the nutrients and organic wastes essential for plants and microorganisms in soil under controlled environmental conditions (Almukthar and Schols 2016; Adrover et al., 2016). Among the major hazardous pollutants, phenol and its compounds pose serious environmental issues due to its high water solubility and high toxicity (Banerjee and Ghoshal, 2016; Tepe and Dursun, 2008). The disposal of phenol containing wastewater without proper treatment causes negative effects on the environment since it does not degrade easily (Bajaj et al., 2008). The effluents from major industries such as chemical, pharmaceutical, petroleum refineries, coal gasification operations, liquefaction process, resin manufacturing, dye units, pulp and paper mills contain phenol compounds. Phenol is a highly corrosive and nerve poisoning agent (Kulkarni and Kaware, 2013). Phenol causes harmful side effects such as sour mouth, cardiac toxicity including week pulse, cardiac depression, reduced blood pressure, diarrhoea, impaired vision and excretion of dark urine. Liver and kidney of humans have been damaged due to the presence of phenol in drinking water (Turhan and Uzman, 2008). High phenol concentration can cause hydrobios which may lead to death. The toxic levels usually range between 9 mg/L to 25 mg/L for human and aquatic species respectively. When phenol concentration in blood exceeds around 150 mg/100 mL, it could be lethal to humans (Bajaj et al., 2008; Zeng et al., 2013). Moreover, phenol has been listed as a major pollutant by the US Environmental Protection Agency (EPA) and total phenolic content of drinking water was regulated to be < 0.5 μgL. Physicochemical method has been used to treat phenol-containing wastewater at low concentrations of < 300 mgL^{-1}. For higher concentrations in the range of 5,000 mgL^{-1}, biochemical treatment could be adopted (Xiao et al., 2006; Tziotzios et al., 2005). Several processes used to degrade the phenolic compounds from industrial wastewater are granular or biological activated carbon filtration, ozonation, chlorination, H_2O_2/UV process, O_3/UV process, Fenton process, solvent extraction and membrane process (Barrios-Martinez et al., 2006). Coir is one of the strongest natural fibres extracted from coconut husk which has been widely used all over the world. Open retting is an old practice for the extraction of coir which has been carried out in natural water bodies. Also it is the most important pollution creating process in the backwaters (Vardhanan Shibu et al., 2013). Traditional coir de-fibering process is a natural biochemical process which involves coir retting (Ambika Devi and Gopalakrishna Pillai, 1990). Retting results in the release of large quantities of organic substances like polyphenols and chemicals including pectin, pentosan, tannins, sulphide, phosphate, nitrate, hydrogen sulphide and ammonia. Hence, this results in an increased biological oxygen demand (BOD) and chemical oxygen demand (COD) (Jayashree et al., 2014; Syamkumar et al., 2014; Basu et al., 2015). The effluents from coconut husk retting contain recalcitrant components like phenol which has been discharged in to pond or river. This results in deterioration of water quality and affects biodiversity of flora and fauna. Carbon-dioxide, salinity and pH of the pond water increases due to increase in the level of retting effluent. Therefore, the phenol removal from retting effluent is an important step which has to be taken prior to their release into water bodies. In the coastal regions of Southern India, the retting wastewater is released into the environment without any proper treatment (Subaida and Dinesh, 2016).

The most common standards used to assess water quality are World Health Organisation (WHO) and Bureau of Indian Standards (BIS) standard systems which assures safety to human contact and ecosystems. Water quality standards vary significantly due to different environmental conditions, ecosystems, intended human use of toxic substances and high population of certain microorganisms. It leads to health hazards and affects irrigation, affects wildlife, swimming, fishing, boating and industrial use. Sediments are indicators of quality of overlying water and its study is useful tool in the assessment of environmental pollution.

2 Materials and methods

2.1 Materials

The samples were collected from coconut retting wastewater at Ganesan fibre industries Kadayanallur, Thirunelveli (Dist), Tamilnadu, India, during different time period of a year. The dimension of wastewater well is 2 × 2 × 5 lbh. The wastewater samples were tested for different physico-chemical parameters.

Figure 1 Retting pond wastewater well (see online version for colours)

2.2 Methods

The pH value of wastewater samples was measured using pH metre. The colour of wastewater sample was analysed by standard method. Total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), COD, BOD and phenol concentration were also determined. Biodegradability of the sample was determined by the American Public Health Association (APHA) methods.

2.3 Chemical oxygen demand

10 mL of sample was taken in a 500 mL refluxing flask and a pinch of mercuric sulphate was added. After, 5–6 glass beads were also added to it and mixed well. Then, 15 mL sulphuric acid was added and the mixture was allowed to cool. Then, 7 mL of potassium dichromate solution was added. The mixture was then refluxed for two hours and allowed to cool. Finally, the reaction mixture was diluted to twice of its volume with distilled water and titrated against 0.1 N ferrous ammonium sulphate using ferroin indicator. Appearance of brown colour indicates the end point.

$$\text{COD}(\text{mg}/\text{L}) = \frac{(\text{A} - \text{B}) \times \text{N} \times 8{,}000}{\text{Volume of the sample}} \quad (1)$$

where

A volume of ferrous ammonium sulphate used for blank titration

B volume of ferrous ammonium sulphate used for sample titration

N normality of ferrous ammonium sulphate

2.4 Biological oxygen demand

a *Preparation of dilution water:* 4 L of distilled water was taken and aerated for 4.5 hours. Then, 1 mL of magnesium sulphate, 1 mL of calcium chloride and 1 mL of ferric chloride were added and mixed well.

b *Sample preparation:* Retting pond wastewater was taken at different dilutions in BOD bottle. Initial BOD was calculated and the sample was stored in a container at room temperature using constant temperature chamber for 5 days in order to get more reliable results.

c *Determination of DO:* 1 mL of manganese sulfate and 1 mL of alkali iodide were mixed well and allowed to settle to form precipitate. Then, 1 mL of concentrated sulphuric acid was added to dissolve the white colour precipitate.

d *End point:* 200 mL of sample was taken from BOD bottle and titrated against 0.02 M sodium thiosulphate using starch as indicator. Disappearance of blue colour was the end point.

$$\text{DO}_{\text{initial}} = \frac{\text{mL of titrant} * \text{N} * 8 * 1{,}000}{\text{V2}(\text{V1} - \text{V})/\text{V1}} \quad (2)$$

V1 volume of BOD bottle in mL

V2 volume of content titrated in mL

V volume of manganese sulphate and iodide azide

$$DO_{final} = \frac{\text{mL of titrant} * N * 8 * 1,000}{V2(V1 - V)/V1} \tag{3}$$

$$BOD_5(mg/L) = DO_{initial} - DO_{final} \tag{4}$$

2.5 Phenol standard

The sample was taken in conical flask at different volumes of 5, 10, 15 and 20 mL. The pH was adjusted to 7.9 using phosphate buffer solution and 1 mL of 4-amino antipyrine was added. To this mixture, 1 mL of potassium ferric cyanide solution was added and stirred well. Finally, it was kept for 15 minutes at room temperature without any agitation. The absorbance of the sample was determined at 500 nm using spectrophotometer.

$$\text{mg of phenol} = A/B \times 1000 \tag{5}$$

where

A mg of phenol in sample from graph

B mL of original sample.

2.6 Total solids

20 mL of sample was taken in a pre-weighed evaporating dish and kept in a water bath at 105°C for 1 hr. The dried sample weight was then measured.

$$TS(mg/L) = \frac{(A - B) \times 1,000}{\text{Volume of the sample}} \tag{6}$$

where

A weight of evaporating dish (mg) + solids (mg)

B weight of evaporating dish (mg).

2.7 Total suspended solids

20 mL of sample was filtered in a pre-weighed filter paper and kept in oven at 105°C for 1 hr. The dried sample weight was then measured.

$$TSS(mg/L) = \frac{(A - B) \times 1,000}{\text{Volume of the sample}} \tag{7}$$

where

A weight of china dish (mg) + filter paper (mg) + solids (mg)

B weight of china dish (mg) + filter paper (mg).

Table 1 Characteristics of retting pond wastewater

S. no	*Time interval (month)*	*pH*	*COD mg/L*	*BOD mg/L*	*Phenol mg/L*	*TS mg/L*	*TSS mg/L*	*TDS mg/L*	*Colour (OD at 400 nm)*	*Bio degradability*
1	March	7.2	16,000	7,500	420	30,000	1,500	28,500	2.8	0.4687
2	April	7.2	16,000	7,200	400	32,900	1,300	31,600	2.8	0.45
3	May	7.4	16,000	7,500	420	30,000	1,400	28,600	3.0	0.4687
4	June	7.6	14,000	7,000	380	30,000	1,300	28,700	2.7	0.5
5	July	7.4	14,000	7,400	400	29,450	1,200	28,250	2.8	0.5285
6	August	7.0	12,800	7,100	370	28,050	1,200	26,850	2.6	0.5546
7	October	6.8	12,800	7,100	390	29,200	1,200	28,000	2.8	0.5546
8	September	6.6	12,800	7,000	390	30,000	1,400	28,600	3.0	0.5468
9	November	6.8	14,000	7,300	410	32,900	1,500	31,400	2.8	0.5214
10	December	7.0	14,000	7,200	370	30,000	1,300	28,700	2.7	0.5142
11	January	7.2	16,000	7,300	400	29,450	1,200	28,250	2.8	0.4562
12	February	7.2	16,000	7,400	410	30,000	1,400	28,600	2.8	0.4625

2.8 Total dissolved solids

TDS = Total solid – total supender solids

2.9 Colour

2 mL of sample was taken in cuvette and then the absorbance was measured at 400 nm using colorimeter.

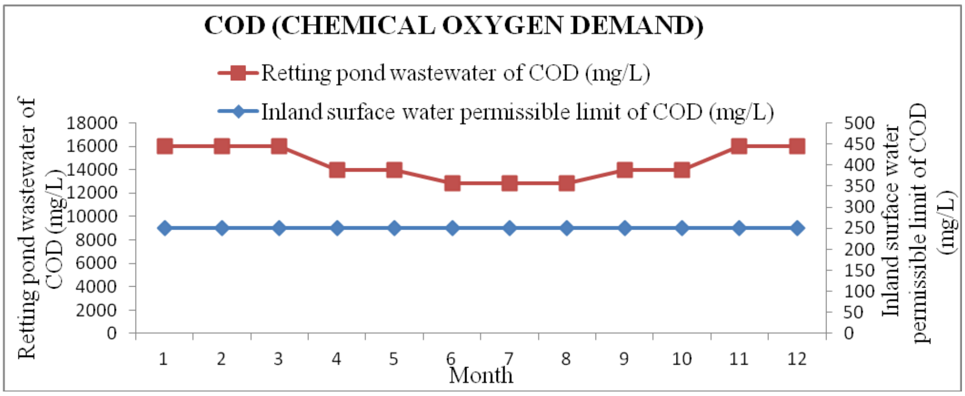
3 Results and discussions

In this study, analysis of water quality during different time intervals was carried out. The results are listed in Table 1.

3.1 Chemical oxygen demand

From Figure 2, COD of the wastewater sample was in the range of 12,800–16,000 mg/L. The permissible COD of in-land surface waters is 250 (mg/L). The coconut husk retting pond wastewater has to be treated because the permissible limit was exceeded.

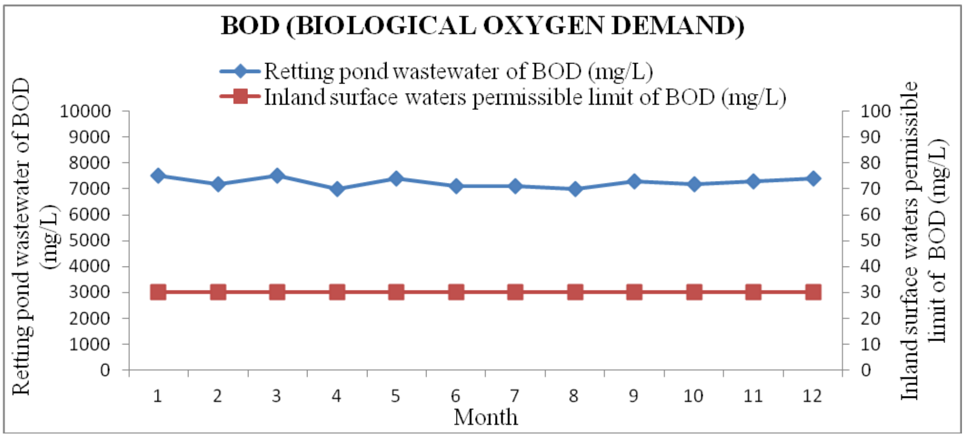
Figure 2 COD present in wastewater and inland surface water permissible of COD (see online version for colours)



3.2 Biological oxygen demand

From Figure 3, BOD of the wastewater was found in the range of 7,000–7,500 mg/L. But, the permissible BOD for inland surface waters should be 30 (mg/L). The coconut husk retting pond wastewater has to be treated due to higher BOD values.

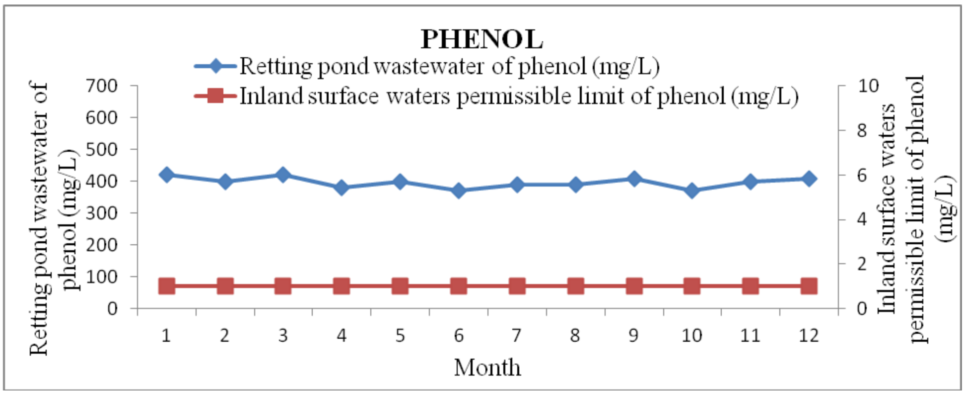
Figure 3 BOD present in wastewater and inland surface water permissible of BOD (see online version for colours)



3.3 Phenol

From Figure 4, phenol concentration was found in the range of 370–420 mg/L and for inland surface waters, the permissible limit should be 1 (mg/L). Since, having higher phenol concentration, the retting water has to be treated.

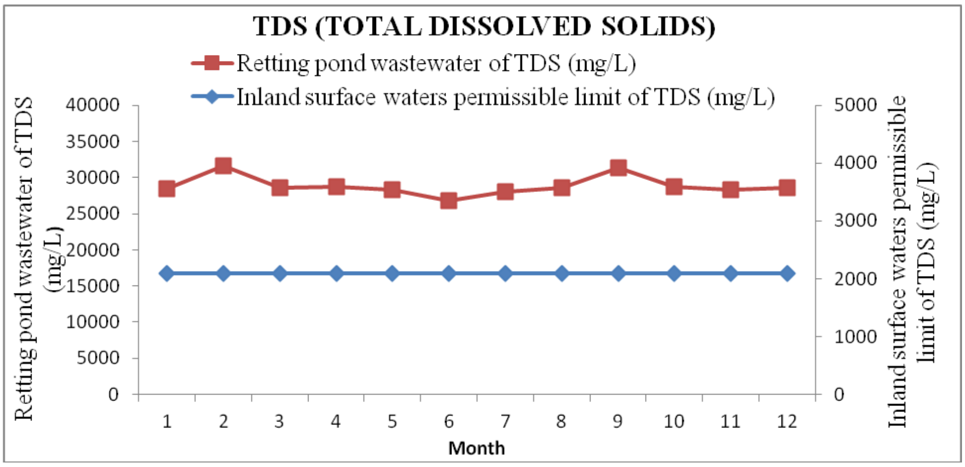
Figure 4 Phenol present in wastewater and inland surface water permissible of phenol (see online version for colours)



3.4 Total dissolved solids

The TDS of the wastewater was found in the range of 26,850–31,600 mg/L which is confirmed in Figure 5. The permissible TDS for inland surface waters is 2,100 mg/L. The wastewater exceeds the permissible limit.

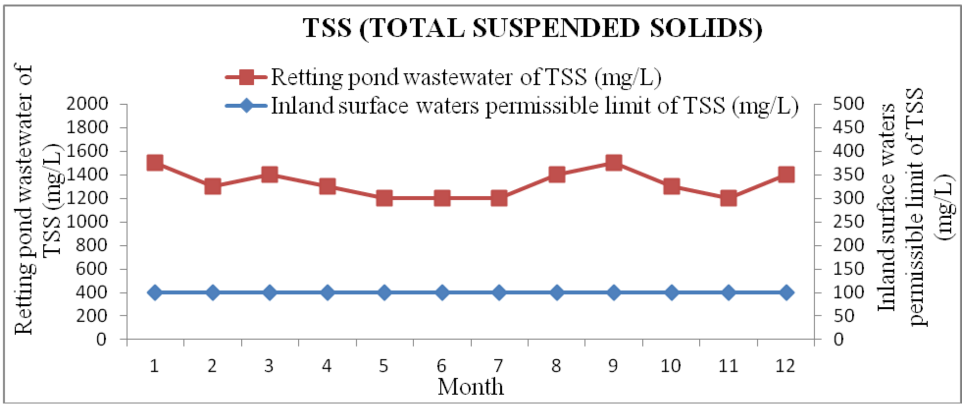
Figure 5 TDS present in wastewater and inland surface water permissible of TDS (see online version for colours)



3.5 *Total suspended solids*

The TSS of the wastewater sample was found to be in the range of 1,200–1,500 mg/L which exceeds the permissible limit. The permissible limit for inland surface waters is 100 mg/L.

Figure 6 TSS present in wastewater and inland surface water permissible of TSS (see online version for colours)



4 Conclusions

Water quality standards vary significantly due to different environmental conditions and ecosystem. The variations were probably due to various factors such as trace metals in soil and crops. The geographical location, fertilisers, fungicides, various organic pollutants such as phenol, tannin, lignin and other agricultural activities also influence the quality of the wastewater.

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