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COMPARISON OF COFFEE WASTEWATER TREATMENT TECHNOLOGIES

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Abstract:
Coffee is an agricultural commodity of substantial socio-economic importance that creates jobs both directly and indirectly, including employment contracts in rural areas and taxes on production. The processing of coffee can have a significant influence on the world economy. The process of coffee cherry has caused environmental issues due to discharges of huge amounts of organic waste and high concentration of contaminants in the effluent. The purpose of wastewater treatment is to protect the environment in a manner that is commensurate with public health and socio-economic concerns. Thus, an effective system or technique is proposed to meet the effluent standard for discharge of coffee wastewater from processing plant. There are different study reports for the treatment of coffee processing effluents. The reviews for the coffee wastewater treatment applied included the technology applied either in the lab experiment or tested on pilot plant simulation. The treatment methods introduced such as chemical coagulation/flocculation, advanced oxidation processes (photo-fenton oxidation), adsorption, anaerobic digestion, phytoremediation (wetland system) and ionizing irradiation (gamma radiation). All these reports stated the scientific approaches while applying treatment/management options for coffee processing. This review focuses on the most potential of treatment applied on coffee wastewater treatment based on Biochemical Oxygen Demand (BOD) reduction and Chemical Oxygen Demand (COD) reduction in coffee wastewater.

***Keywords*:**
Coffee Wastewater, Methods, Biochemical Oxygen Demand, Chemical Oxygen Demand, Potential Treatment

Objectives:

The main objective of this review is to study the performance of various method and technologies in treating coffee wastewater. The side objectives of the study are:

- To study effect of treatment on coffee wastewater.

- To study the Biochemical Oxygen Demand and Chemical Oxygen Demand parameter in order to evaluate the effectiveness of each treatment.

Methodology:

Research approach

To know which method the most suitable treatment is needed, an analysis on coffee processing wastewater treatment technology can be applied. This analysis included the technology applied either in the lab experiment or tested on pilot plant simulation. Therefore, the data obtained for coffee treatment effluent were processed in the form of tabulation. An analysis on efficiency of coffee wastewater treatment method can be found by comparing each scientific research based on wastewater contaminants limit regulations.

Research Design

The research used qualitative research approaches based on data collection from scientific research paper. Regarding case studies, the research aims to gather an in-depth understanding about treatment method applied to coffee effluent and treatment efficiency via significant result achieved. The data analysed in this research consist of two data. The first study is about the physico-chemical parameter of coffee effluents. The parameter data obtained from literature study for various coffee processing plants around the world. Secondary data, as complementary and supporting for primary data, were obtained through literature study and data from other related institutions and relevant to this research.

Data Collection

Method	**Treatment Condition**	**Initial Parameter**	**Final result**	**Reference**
Moringa Oleifera seed extract	1. pH = 3 – 7 2. Dose of MOSP = 0	TSS = 163 mg/L COD = 2430	TSS reduction 8.00 – 54.12% COD	[1]

	– 4 g/L 3. Mixed speed = 200 rpm	mg/L	reduction 26.02–100.00%	
(a) Casuarina fruit powder (b) Sorghum stem powder (c) Banana Stem powder	1. Time = 180 min 2. Doses = 4 g/L 3. pH = 7 4. size ≤ 0.30 mm 5. Mixed speed = 300 rpm	COD = 11300 mg/L N = 4.0 mg/L TSS = 3190 mg/L	COD reduction 99.2% N reduction 92.7% TSS reduction 81.0%	[2]
(a) Coagulation-flocculation (b) Coagulation-flocculation + UV/H_2O_2 (c) Coagulation-flocculation + UV/O_3 + UV/H_2O_2/O_3		COD = 4300 mg/L	a) COD reduction 67.03 % b) COD reduction 86.05% c) COD reduction 87.01 %	[3]
Avocado peel carbon	1. 70 min 2. 4 g100 m/L 3. 7 4. ≤ 0.25 mm 5. 800 rpm	COD = 22,000 mg/L BOD = 12,000 mg/L	COD Reduction 98.20 % BOD Reduction 99.18 %	[4]
Simple anaerobic batch reactor (ABR)	1. Room temp range (20–23 °C) 2. pH= 7.0 3. HRT = 70 d	BOD_5= 5,861.0 COD = 8,079.0 TSS = 2,019.0	BOD_5 and COD reduction 90 % TSS reduction 95 %	[5]
Wetland with aeration and vegetation	1. pH = 7.0 2. Flow rate = 0.020 m^3/d 3. HRT = 12 d		Total nitrogen reduction 69.03 % Total phosphorus reduction 72.05 % Total	[6]

			potassium reduction 30.02 %	
UASB and wetland	pH = 5.9 – 6.1	Biological Oxygen Demand (BOD) of up to 20.000 mg/l and a Chemical Oxygen Demand (COD) of up to 50.000 mg/l	BOD reduction 49 - 81% Suspended solids reduction 36 - 70% (depending on initial BOD loadings and retention time)	[7]
a) Coagulation-flocculation	1. Temp 20°C 2. Source radiation MP-y-30	COD = 2070 mg/L	a) Turbidity reduction 56.7% BOD reduction 47.0 % COD reduction 23.8 %	[8]
b) Coagulation-flocculation and Gamma radiation			b) Turbidity reduction 87.5 % BOD reduction 70.0 % COD	

			reduction 32.5 %	
a) Fenton's oxidation	1. Fenton dose = 2.5 g/L Fe^{3+} + 9.0 g/L H_2O_2 2. pH 3.0 3. Temp 30°C		a) COD reduction 55.7%, BOD_5 reduction 39.7% TOC reduction 51.3%	[9]
b) Coagulation/flocculation	1. pH 10		b) Turbidity reduction 92%	
c) Fenton's oxidation and Coagulation /flocculation	Fenton oxidation 1. pH10.0 2. Fenton dose = 2.5 g/L Fe3+ + 9.0 g/L H2O2 C/F 3. pH 5.0, 4. Temp 55°C)		c) TOC reduction 76.2%, COD reduction 76.5% BOD_5 reduction 66.3%.	
Coagulation and electrooxidation	1. Dose $AlCl_3$ = 112 mg/L 2. Boron-doped diamond electrode (electrooxidation)	COD = 2380 mg/L TOC = 757 mg/L	COD reduction 98.03% TOC reduction 96.04%	[10]
Two stage constructed wetland	*Phragmites karka* plant HRT = 3d	TSS = 399.3 mg/L COD = 13,000 mg/L	SS reduction 94%, Colour reduction 79%	[11]

	Eichhornia crassipes plant HRT = 4d pH = 4.4	BOD = 1720 mg/L	COD reduction 95%

Results:

Biochemical Oxygen Demand (BOD and BOD_5)

Based on Table 1 the highest BOD reduction is using biological process to treat the coffee wastewater the reduction could go up to 90 % reduction of BOD. Using UASB or ABR could reduce the BOD value significantly.

Table 1: Biochemical Oxygen Demand (BOD) percentage removal

Technique	Percentage removal	Reference
Fenton's oxidation	BOD_5 reduction 39.7%	[9]
Fenton's oxidation and Coagulation/flocculation	BOD_5 reduction 66.3%.	[9]
Coagulation – flocculation	BOD reduction 47.0 %	[8]
Coagulation-flocculation and Gamma radiation	BOD reduction 70.0 %	[8]
UASB and wetland	BOD reduction 49 - 81%	[7]
simple anaerobic batch reactor (ABR)	BOD_5 and COD reduction 90 %	[4]

Chemical Oxygen Demand (COD)

Based on Table 2 the highest COD reduction occur through adsorption process. Most of nature adsorbent used in treatment has potential to COD value. The next highest reduction shown by constructed wetland which COD value decrease high also. The traditional by using coagulation and flocculation need to be paired with other technique in order to achieve greater result in coffee wastewater COD reduction.

Table 2: Chemical Oxygen Demand (COD) percentage removal

Technique	Percentage removal	Reference
Moringa Oleifera seed extract	COD reduction 26.02 –	[1]

	100.00%	
(a) Casuarina fruit powder (b) Sorghum stem powder (c) Banana Stem powder	COD reduction 99.2%	[2]
Coagulation-flocculation	COD reduction 67.03 %	[3]
Coagulation - flocculation + UV/H_2O_2	COD reduction 86.05%	[3]
Coagulation-flocculation + UV/O_3 + UV/H_2O_2/O_3	COD reduction 87.01 %	[3]
Avocado peel carbon	COD Reduction 98.20 %	[4]
simple anaerobic batch reactor (ABR)	BOD_5 and COD reduction 90 %	[5]
Coagulation-flocculation	COD reduction 23.8 %	[8]
Coagulation-flocculation and Gamma radiation	COD reduction 32.5 %	[8]
Fenton’s oxidation	COD reduction 55.7%	[9]
Fenton’s oxidation and Coagulation/flocculation	COD reduction 76.5%	[9]
Coagulation and electrooxidation	COD reduction 98.03%	[10]
Two stage constructed wetland	COD reduction 95%	[11]

Based on Table 1 and Table 2, the BOD and COD value varied because it depend on the concentration of organic loads content in coffee wastewater. Since most of reviewed paper focused on COD and BOD value in coffee wastewater, the appropriate method considered also based on those criteria. Anaerobic digestion is the most considered process since it shows high BOD and COD reduction and can handle high volume wastewater without producing more waste unlike coagulation-flocculation process.

Conclusion:

Mostly, the implementation of the treatment technologies have certain limitation to be implemented as certain treatment effective on certain condition. It is crucial that alternatives suitable for regions that can be implemented at low cost are critically assessed and prepared. Many treatment considered in this review such as coagulation-flocculation, adsorption, ionizing radiation, advanced oxidation process, anaerobic digestion, and phytoremediation (wetland) were analysed in this review. All of these solutions have their own drawbacks due to the nature of coffee processing wastewater and technologies limitation. Anaerobic treatment is the most common as the energy derived can be obtained from coffee processing industry. Most of the coffee wastewater treatment plant in the review introduce anaerobic process in their plant to in favor to reduce the cost and show good treatment efficiency. However, due to scientific advancement the chemical methods such as advanced oxidation process, coagulation-flocculation, and adsorption been shown considerations. The characteristics of coffee wastewater is not sufficient for the chemical process as it needs a high cost due to its volume. One of the researches shows that Constructed wetland (phytoremediation) can produced SS reduction 94 %, Colour reduction 79 % COD reduction 95 %. The Chemical Oxygen Demand (COD) reduction showed that phytoremediation is one of the potential method to be applied in coffee wastewater treatment. So, the best alternative solution is the phytoremediation approach since it also able to replace soil nutrients with low costs for the processed.