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Effectiveness of Advanced Vs Conventional Wet Coffee Processing Technologies in Effluent Wastewater Quality

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Abstract

This study examined the effluent suitability for discharge of newly emerged advanced wet coffee processing technologies compared to the conventional systems; near Jimma, Ethiopia. A descriptive study design was employed and composite samples were analyzed in triplicate for selected physicochemical parameters (COD, BOD_5, DO, NH_3, PO_4^{3-}, NO_3^--N, pH, TSS, TDS, conductivity, and turbidity). Consequently, the mean results obtained from conventional wet coffee processing technologies effluent wastewater were BOD_5 (1697 mg/L), COD (5682.5 mg/L), TSS (1975 mg/L), TDS (1800.75 mg/L), and pH (4.13). Whereas mean values from effluent wastewater of advanced wet coffee processing technologies were BOD_5 (2687 mg/L), COD (3567 mg/L), pH (6.69), and TSS (282.42). Even though there was significant variation between conventional and advanced wet coffee processing effluent wastewater; both wet coffee processing technologies did not comply with Ethiopian permissible discharges limit standards for BOD_5, COD and TSS. Hence, establishing advanced wet coffee processing technologies does not seem to solve the pollution problems associated with coffee processing. Therefore, effluent wastewater treatment systems are needed for both technologies before discharging to prevent surface water pollution.

Index terms: Coffee processing technologies, Effluent, Wet Coffee, Wastewater

1 INTRODUCTION

Ethiopia is the largest country producing diversity of coffee from its genetic resource (2). Coffee was originally found and cultivated in Kafa province of Ethiopia from which it got its name around 1000 A.D. (1). After harvesting, coffee can be processed in two ways; these are

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dry (natural) processing and wet (washing) processing. Wet processing is done with the help of water, especially to remove the outer red skin and the white fleshy pulp (9). Wet coffee processing can be done in conventional system, as most of the processing plants do in Ethiopia. The advanced way is currently being practiced in near Jimma, Ethiopia. These technologies are expected to increase the quality of the product and safeguard the environment from pollution. However, the potential of these advanced wet coffee processing systems in achieving the required discharge standard limits has not been studied relative to the conventional technologies for proper wastewater management. Hence, this study deals with the characteristics of selected physicochemical parameters in both technologies effluent wastewater in order to examine the effluent wastewater quality by comparing with Ethiopian EPA available standards. The study will help to evaluate the potential of the newly emerging advanced wet processing plants in meeting the effluent discharge standards compared to the usual conventional wet coffee processing technologies.

2 MATERIALS AND METHODS

2.1 Study area description

This study was conducted in Doyo, Seka, Geruke and Haro districts of Jimma Zone, around 12 km west, 20 km south west, 25 km to east direction and 15 km to south east of Jimma, respectively. In Doyo and Seka study areas advanced wet coffee processing is practiced while in Geruke and Haro study areas conventional wet coffee processing technologies are used. Jimma is located at 352 km from Addis Ababa in south-west Ethiopia. Jimma lies between 7°20'0''N and 8°55'0''N latitude and 35°45'0''E and 37° 35'0''E longitude. The maximum annual temperature of Jimma is 27.5°C whereas minimum annual temperature is 10.47°C and annual rainfall is 495.6 mm.

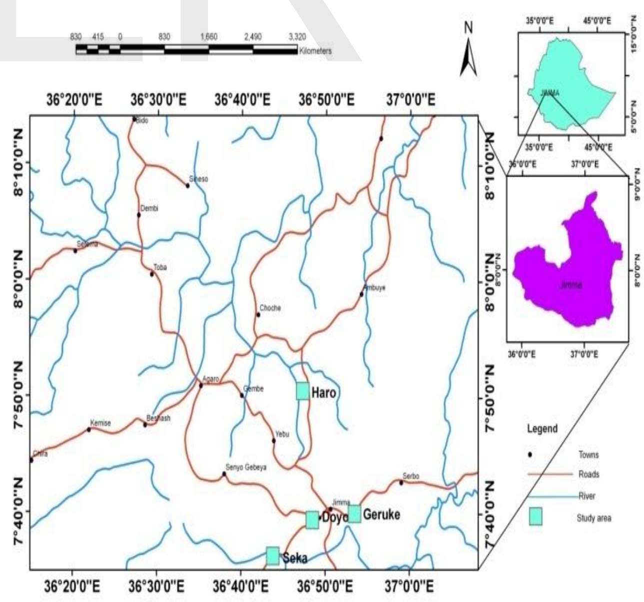

Fig. 2.1 Location of the coffee processing plants

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2.2 Study design

A descriptive study was conducted from October, 2011 -June, 2012 in order to characterize the influent water and effluent wastewater of conventional and advanced wet coffee processing technologies.

2.2.1 Sampling techniques

Composite samples were collected using polyethylene bottles (1000 ml) from each sampling sites in triplicate from influent water and effleunt wastewater. Samples were analyzed for pH, TSS, TDS, NH_3, NO_3^--N $^-$, PO_4^{3-} DO, BOD_5 COD, conductivity and turbidity.

2.2.2 Laboratory analysis: pH, DO, electrical conductivity (EC) and turbidity were measured onsite using APHA procedures (3). BODs, COD TSS, TDS, NO_3^-N, NH_3 and PO_4^{3-}, were also analyzed using HACH procedures (5).

2.3 Data analysis

Statistical analyses were performed using SPSS version 16 to measure mean and standard deviations of the laboratory analysis results. The mean values selected parameters from conventional and advanced wet coffee processing technologies were compared with Ethiopian EPA permissible discharge limit standards to surface water pollution (4).

3. RESULTS AND DISCUSSION

This study revealed that both wet coffee processing technologies wastewater did not comply with the Ethiopian EPA discharge limit standards to surface water (4) for most of the parameters such as BOD_5, COD and TSS (Table 3.2 and 3.3). This means that the advanced wet coffee processing technologies did not released su fficiently clean discharge to the environment.

This can contribute to surface water pollution. It has been found in studies and in other parts of the world too that coffee wastewater has high pollutant potential (Matos, *et al*., (6). Thus, the high acidity and depleted life supporting oxygen from the water are major concerns for coffee wastewater treatment. The pH of advanced wet coffee processing technologies effluent (6.69) is better than the pH of conventional wet coffee p rocessing (4.13). However, the advanced wet coff ee processing technologies effluent wastewater B OD_5 (2687 mg/L) is higher than the conventional wet coffee wastewater technologies (1697 mg/L). The high BOD_5 from advanced wet coffee processing technologies may be due to the high fermentation process (7). The raw water BOD_5,

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COD, TSS for conventional wet coffee technologies was 214.25 mg/L, 233.5 mg/L and 259.5 mg/L, respectively. This indicated that even the raw water characteristics for some parameters did not comply with the Ethiopian EPA (4) discharge standards (Table 3.1). Hence, the raw water is not safe for coffee processing compared to the Ethiopian EPA (4) and WHO (8) guidelines for processing wet coffee. It was observed that plants grown under wastewater effluent from advanced wet coffee processing plants were greenish (Plate 3.2). However; plants grown around wastewater of conventional wet coffee processing did not resist and grow properly (Plate 3.1). This was due to wastewater released from conventional wet coffee processing plants being acidic (Table 3.3), whereas effluent pH from advanced wet coffee processing was close to neutral (Table 3.2).

Fig 3.1.Mean BOD_5 comparison of conventional and advanced wet coffee processing plants effluent wastewater

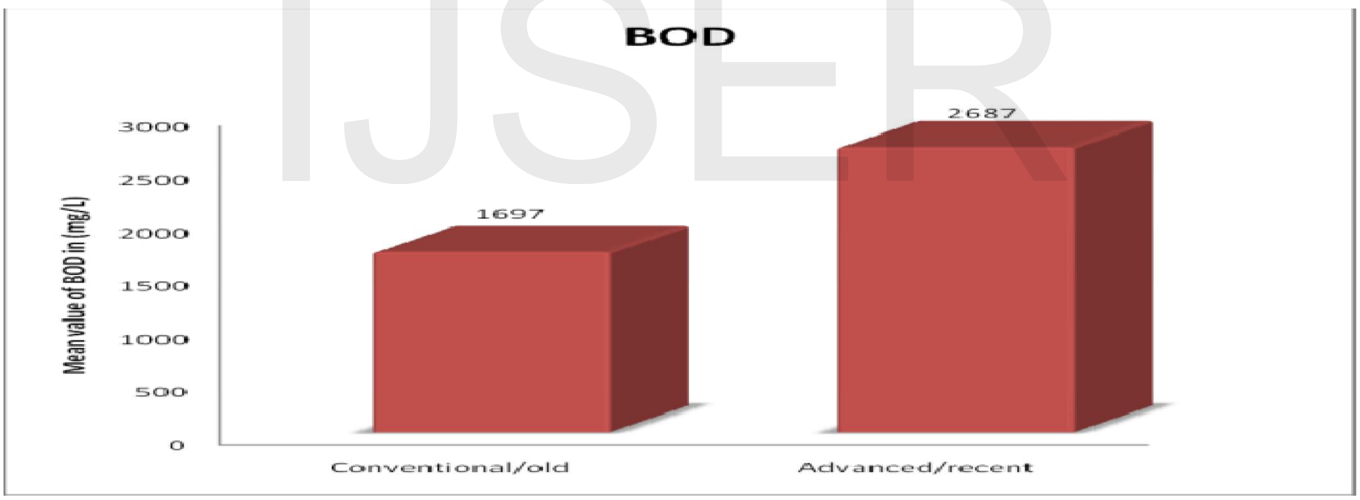

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Table 3.1.Characteristics of raw water used in advanced and Conventional wet coffee processing plants

Advanced wet coffee processing technologies			Conventional wet coffee processing technologies		Ethiopian EPA (4) discharge standards
Parameter	Mean + SD	Range	Means ± SD	Range	
pH	6.92 ± 0.637	6.87 - 7.01	7.01 ± 0.55	6.19 - 7.35	6-9
BOD_5 mg/L	96.25 ± 17.36	81.8 - 120.2	214.25 ± 81.33	113 – 312	80
COD mg/L	130 ± 14.8	110 – 146	233.5 ± 79.4	155 – 324	250
NH_3 mg/L	0.94 ± 0.42	0.34 - 1.24	0.78 ± 0.28	0.37 - 0.96	5
NO_3-N mg/L	1.41 ± 0.43	1.0 – 2.0	0.98 ± 0.22	0.66 - 1.13	20
PO_4^{3-} mg/L	0.27 ± 0.11	0.18 - 0.42	0.34 ± 0.16	0.18 - 0.54	5
TSS mg/L	238.25 ± 53.1	198 – 312	259.5 ± 65.3	170 – 322	100
TDS mg/L	190.75 ± 20.9	178 -222	189.5 ± 46.5	143 – 254	3000
EC µs/cm	70.25 ± 10.24	58 - 83	65.8 ± 4.24	61 – 71	-
NTU mg/L	22.6 3 ± 8.51	16 - 35	32.28 ± 9.64	23 – 45	-
DO mg/L	7.48 ± 1.07	6.2 - 8.7	6.34 ± 0.6	5.74-7.02	-

Table 3.2. Characteristics of effluent wastewater from advanced wet coffee processing plants

Parameter	Mean ± SD	Range	Ethiopian EPA (4) discharge standards
pH	6.69 ± 0.12	6.54 - 6.82	6-9
BOD_5 mg/L	2687 ± 518.04	2220-3356	80
COD mg/L	3567 ± 667.7	2580-3990	250
NH_3 mg/L	11.85 ± 4.13	8.44 - 17.08	5
$NO3^{2-}$ mg/L	2.04 ± 0.34	1.67 - 2.51	20
$PO4^{3-}$ mg/L	2.26 ± 0.68	1.75 - 3.27	5
TSS mg/L	282.42± 44.75	216 – 312	100
TDS mg/L	789.25 ± 72.3	698 – 854	3000
EC (µs/cm)	350 ± 68.66	315 – 453	-

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EC mg/L	91.25 ± 31.4	57 – 126	-
DO mg/L	4.38 ± 0.63	3.70 - 5.20	-

Table 3.3. Characteristics of effluent wastewater from conventional wet coffee processing plants

Parameter	Mean ± SD	Range	Ethiopia EPA (4) discharge standards
pH	4.13 ± 0.23	3.9 - 4.4	6-9
BOD_5 mg/L	1697 ± 390.67	1210-2130	80
COD Mg/L	5682.5 ± 304.45	5470-6120	250
NH_3 mg/L	4.51 ± 1.62	3.15- 6.65	5
NO_3^-N mg/L	3.39 ± 0.65	2.70 - 4.12	20
$PO4^{3-}$ mg/L	3.32 ± 0.5	2.71 - 3.45	5
TSS mg/L	1975 ± 322	1564 – 2310	100
TDS mg/L	1800.75 ± 244.8	1580 – 2133	3000
EC	747 ± 64	663 – 821	-
NTU mg/L	271 ± 128.5	185 – 458	-
DO mg/L	2.14 ± 0.72	1.09 - 2.7	-

Plate 3.1 Vetiver grass grow under wastewater from conventional wet coffee processing plant

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Plate 3.2 Vetiver grass grow under wastewater from advanced wet coffee processing plant

4. Conclusion

Establishing advanced wet coffee processing technologies does not seem to solve the pollution problems associated with coffee processing.

Therefore, there is a need to introduce wastewater treatment systems for both technologies to safeguard the environment. The raw water used for processing both technologies was not safe for coffee processing. Hence, safe water sources need to be identified and used for coffee washing.

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References

[1] Adams, K. (1980). Coffee Development and Management Techniques, Ministry of Coffee and Tea development, Addis Ababa, Ethiopia.

[2] Alemayehu Haddis & Rani, D. (2008). Effect of effluent generated from coffee processing plant on the water bodies and human health in its vicinity. Journal of Hazardous Materials.,152 (1):259-262.

[3] APHA (1995). Standard methods for the examination of water and wastewater. 19th edn. Washington, D.C.

[4] Ethiopian EPA (2003). Provisional standards for industrial pollution control in Ethiopia. Prepared under the ecologically sustainable indus

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ISSN 2229-5518

trial development project.EPA/UNIDO, Addis Ababa, Ethiopia.

[5] HACH (2003). Water and wastewater quality procedures. HACH company, Loveland, USA HATCH Housing, Authority of the city of Houston.

[6] Matos, A. T. D., P. A. Lo Monaco, A. B. Pinto, R. Fia and D. C. Fukunaga., (2001). Pollutant Potential of Wastewater of the Coffee Fruits Processing. Wat. Res., 33(11): 2441-2447.

[7] Selvamuruga, M., Doraisamy, P., Maheswari, M., & Nandakumar, N.B. (2010). Evaluation of Batch Aeration as a Post Treatment for Reducing the Pollution Load of Biomethanated Coffee Processing wastewater. Global Journal of Environ mental Research, 4 (1): 31-33.

[8] WHO (2006). A compendium of standards for wastewater reuse in the Eastern Mediterranean Region. WHO Regional Office for the Eastern Mediterranean. Regional (EMRO) Center for Env ironmental Health Activities (CEHA). WHO/EM RO publications. Document WHO EM/CEH/142

[9] Wintgens, B. (2009). Coffee Growing, Processing, Sustainable Production. 2nd edn., WILEY-VCH Verlag GmbH & Co.KGaA.