Ecohydrology & Hydrobiology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Ecohydrology & Hydrobiology

journal homepage: www.elsevier.com/locate/ecohyd

Original Research Article

# Assessment of the effluent quality of wet coffee processing wastewater and its influence on downstream water quality

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## 1. Introduction

Coffee is one of the most popular beverages in the world and second largest traded commodity after petroleum (Murthy and Naidu, 2012). It is cultivated in about 80 countries across the globe and gives rise to a huge business worldwide (Murthy and Naidu, 2012). According to United States Department of Agriculture data (USDA, 2011), global coffee production in 2010/2011 is estimated to be above 8.2 million tons. Over 2.25 billion cups of coffee are consumed every day globally. Over 90% of coffee production takes place in developing countries, whereas consumption is mainly in the industrialized economies (Ponte, 2002).

Ethiopia is the origin of highland coffee (*Coffea arabica* Linnaeus), a plant earlier known as *Jasminum arabicum laurifolia* Jussieu. This coffee tree species, the only native coffee in the world, has traditionally been tended and harvested as a wild tree in the highland forests of southwestern Ethiopia (Schmitt, 2006), mostly in the former Kaffa Province. In Ethiopia, coffee plays a central role in the incomes of more than one million coffee-growing households and the livelihood of over 15 million people directly or indirectly depends on this commodity crop (LMC, 2000). According to data from the Ministry of Agriculture and Rural Development (MoARD) of Ethiopia for 2013, there were 1722 coffee processing (wet and dry) plants in Ethiopia, owned by private individuals, cooperatives and the government. Furthermore, according to data from the Ethiopian coffee and tea development and marketing authority for 2016/17, the total number of coffee processing plants in Ethiopia has now surged to 2156 (ECTA, 2017) (Table 1).

Almost all wet coffee processing plants in Ethiopia are located close to water bodies. This is because a lot of water is needed for washing the beans, removing the pulp and the mucilage, but also in order to use the water bodies for direct disposal of the wastewater released from the wet coffee processing plants. While there are some wet coffee processing plants that use disposal pits to stabilize the generated wastewater, these disposal pits are constructed without following the correct design and dimensions. In addition, they lack the proper linings (HDPE or cemented floor, for example) to protect against leakage of the effluents into the underground water and the holding capacity of the disposal pits is not taken in to consideration during construction. Thus, the coffee processing water and its wastewater are routinely discharged into nearby streams and rivers. Fig. 1 illustrates disposal pits used by wet coffee processing plants. In this regard, proclamation number 602/2008 (FDRE, 2008b) and the Council of Ministers Regulation number 159/2008 (FDRE, 2008a) of Ethiopia proclaimed that coffee processors shall dispose waste without causing harm to the environment, the public or individuals. However, in most cases there is a lack of continuous follow up and implementation.

Industrial processing of coffee cherries for both dry and wet processes is outlined in Fig. 2. The wet coffee processing procedure requires mechanical removal of pulp with the help of water, as a result of which it produces a considerable volume of wastewater. In wet industrial

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https://doi.org/10.1016/j.ecohyd.2017.10.007

**Table 1**
National wet and dry coffee processing industries (June, 2017).

| S. No. | Region | Wet coffee processing | | | | Dry coffee processing | | | | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Privately owned | Association | State farm | Sub-Total | Privately owned | Association | State farm | Total | |
| 1 | Oromia | 367 | 165 | 15 | 547 | 604 | 58 | 6 | 668 | 1215 |
| 2 | SNNP | 520 | 175 | – | 695 | 181 | 44 | – | 225 | 920 |
| 3 | Gambela | 7 | – | – | 7 | 14 | – | – | 14 | 21 |
| *Total* | | 894 | 340 | 15 | 1249 | 799 | 102 | 6 | 907 | 2156 |

*Source*: Ethiopian Coffee and Tea Development and Marketing Authority, Addis Ababa, 2017.

processes a large amount (about 29% dry-weight of the whole coffee berry) of coffee-pulp is produced as the first byproduct (Corro et al., 2013). It is obtained during wet processing of coffee and for every 2 tons of coffee processed, 1 ton of coffee pulp is generated, whereas in the dry process 0.18 ton coffee husk is generated for every ton of fresh coffee cherries (Adams and Dougan, 1981). Most of the coffee processing plants in Ethiopia prefer to follow the wet processing method because wet processed coffee is considered superior in quality to dry processed coffee. In addition, it obtains higher prices and has a better aroma/flavor than the coffee obtained by the dry processing method. However, wet coffee processing plants discharge untreated effluents into the nearby water bodies and open land. In addition, water consumption is high for this method. In this regard, Kivaisi et al. (2010) estimated that coffee processing is generating about 9 million $m^3$ of wastewater, and 600,000 tons of husks annually in the East Africa region.

Similarly, Devi et al. (2008) indicated that the wastewater generated from coffee processing has high concentrations of organic pollutants like pectin, proteins and sugars. Due to high pollutant content, its disposal without treatment in water bodies has become undesirable due to the danger this poses for the water bodies and to human health. The few existing case studies (Haddis and Devi, 2008; Beyene et al., 2012; Endris et al., 2008) indicate that disposing untreated coffee wastewater into local water bodies results in the pollution of downstream water sources and people residing in the vicinity of the wet coffee processing plants suffer from different types of diseases. However, there have been no detailed studies evaluating the impact of coffee wastewater effluents on the organic load, nutrient enrichment and eutrophication of the nearby water bodies. Therefore, this paper presents an assessment of effluent quality and the magnitude of impact on the downstream water quality.

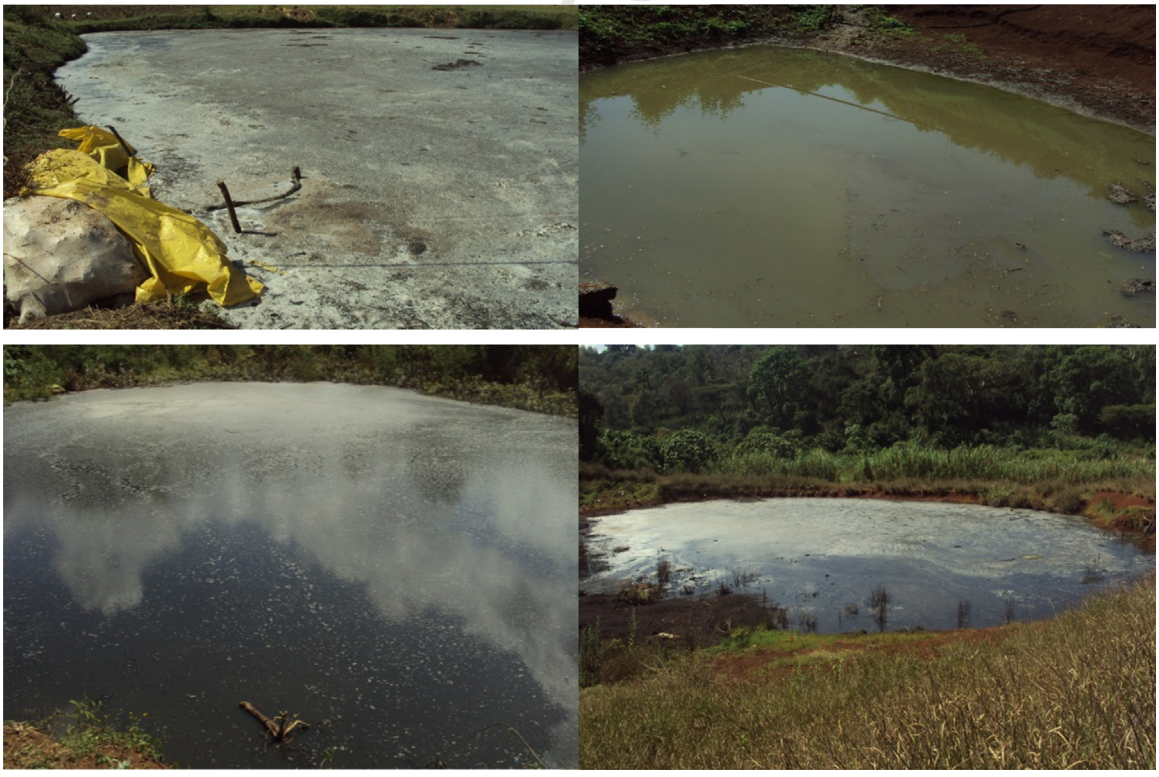

**Fig. 1.** Disposal pits used by wet coffee processing plants: D and F.

Please cite this article in press as: Dadi, D., et al., Assessment of the effluent quality of wet coffee processing wastewater and its influence on downstream water quality. Ecohydrol. Hydrobiol. (2017), https://doi.org/10.1016/j.ecohyd.2017.10.007