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Effect of effluent generated from coffee processing plant on the water bodies and human health in its vicinity

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Abstract

The objective of this study was to assess the effect of wastewater produced from coffee processing plant on nearby water bodies and human health. A study was conducted around the coffee processing plant in Zimma zone (Ethiopia) to assess the physico-chemical characteristics of effluent generated from this plant. Analysis of the water samples taken from the surrounding water bodies had also been done. It was found, from the present investigation, that the wastewater from coffee processing plant was heavily polluted with organic matter as it showed high concentration of COD (upstream 25,600 mg/l and downstream 15,780 mg/l), BOD (upstream 14,200 mg/l and downstream 10,800 mg/l), phosphate (upstream 7.3 mg/l and downstream 4.6 mg/l), nitrate (upstream 23 mg/l and downstream 10.5 mg/l) and suspended solids (upstream 5870 mg/l and downstream 2080 mg/l) and these concentrations were much higher than the permissible limits prescribed by WHO. It was also found, from this study, that the people residing in the vicinity of this plant were consuming this polluted water and as a result suffered from many diseases like skin irritation, stomach problem, nausea and breathing problem.

Keywords: Coffee processing plant; Effluent; Health impacts; Water bodies

1. Introduction

Coffee plant was originally found and cultivated by Oromo people in the Kafa province of Ethiopia from which it got its name [15]. Around 1000 A.D., Arab people took the coffee seeds from this region and started the first coffee plantation there and then from these it spread to the whole Europe [1]. So, Ethiopia was the origin of coffee and is world's third largest coffee exporter after Burundi and El Salvador [15]. Jimma zone is one of the areas in Ethiopia where coffee-processing plants are in large number. In this zone, wet coffee processing method has been adopted. Wet coffee processing procedure requires the mechanical removal of the pulp with the help of water which produces considerable amount of wastewater [22,17,18]. The water used for de-pulping of the cherries is known as pulping water and it accounts for over half of the water used in the process [12,13].

The wastewater generated from coffee processing plant contains organic matter like pectin, proteins and sugars [4,6,22]. Pulping water can further be reused for de-pulping of the harvest of same day but this results in further increase in organic matter and a decrease in pH [2]. The high acidity of this effluent may deplete the life supporting oxygen of the water bodies it is joining [5,12].

It has been found from literature that the wastewater from such type of industries has high concentration of organic pollutants [7,8,14,16] and is very harmful for sourrounding water bodies, human health and aquatic life if discharged directly into the surface waters [9,11]. It was also found from previous studies that only little work has been done to analyse various aspects of coffee processing and about the impact of such effluent on surrounding environment and human health. Thus, there is a need to develop economically viable and eco-friendly technology for handing such type of wastewaters.

The main aim of this study was to assess the pollution load of the effluent from coffee processing plant. Its effect on nearby water sources was also studied alongwith the effect on the communities residing in its vicinity. We are doing further research to get better options for disposal of effluent generated by this

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coffee processing plant and already some efforts had been done for the treatment of wastewater [19,20].

2. Materials and methods

2.1. Materials

The wastewater generated in this coffee processing plant was discharged to the nearby stream without treatment. For the river, it became a source of pollution as the decomposition of this waste consumed much of the available oxygen from water which might create a high BOD and COD load in water bodies and led to a lot of health problems.

The present study was performed during 2005–2006. The study site selected for this investigation was a coffee-processing plant in a village Mana Woreda which was located about 20 km from Jimma town, Ethiopia as shown in Fig. 1 (being a small village not printed in the map and shown by location through arrow). Survey was conducted among the community residing in its vicinity. The sample size for survey was determined by distance taking the pollution fallout as a center and included all people living within 100 m radius. People residing in this area were also interviewed to assess their awareness about the effect of wastewater discharged in nearby flowing natural water streams. The health effects of polluted downstream water were also analysed by using a pre-designed questionnaire.

Wastewater samples from upstream and downstream of a coffee processing plant were collected to analyse their physico-chemical characteristics. In the similar manner, water samples had been collected from the stream flowing nearby this plant from a point before and after entering of coffee processing effluent in this stream for the analysis. The samples were stored at 2–3 °C to avoid any change in their physico-chemical characteristics.

Table 1
WHO (1995) permissible limits for the treated effluents to be discharged on land for irrigation

S. no.	Parameters	WHO permissible limits
1.	Temperature (°C)	20
2.	pH	6.5–8.5
3.	BOD (mg/l) (5 days at 20 °C)	100
4.	COD (mg/l)	300
5.	Total suspended solids (mg/l)	200
6.	Phosphate (mg/l)	5
7.	Nitrate (mg/l)	5

2.2. Methods

The pH and temperature of the wastewater samples were measured on collection site. Total suspended solids, BOD, COD, nitrate and sulphate were analysed in laboratory according to the methods prescribed in APHA [3] handbook.

3. Results and discussions

The World Health Organisation [23] permissible limits have been given in Table 1 to compare the pollution level of wastewater generated from the coffee processing plant and for the neighbouring stream receiving this wastewater.

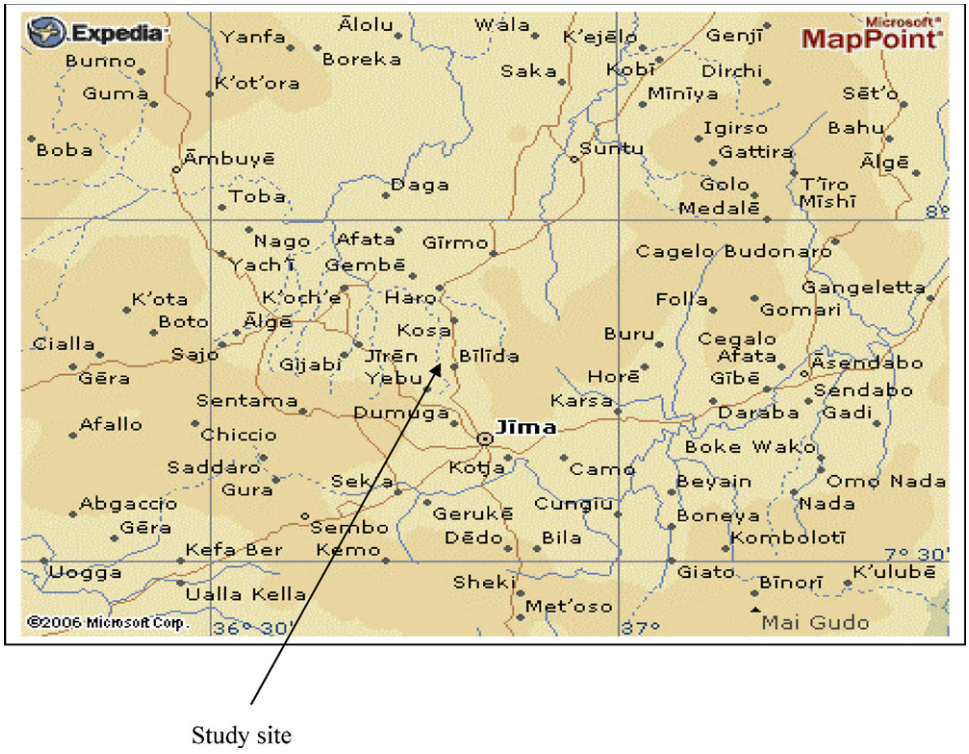

Fig. 1. Map of the study site of coffee processing plant in Zimma Zone, Ethiopia.

Table 2
Characteristics of the coffee processing plant effluent in Zimma Zone, Ethiopia

Parameters	Effluent characteristics	
	Upstream	Downstream
Temperature (°C)	25	22
pH	3.57	4.45
BOD (mg/l) (5 days at 20 °C)	14,200	10,800
COD (mg/l)	25,600	15,780
Total suspended solids (mg/l)	5870	2080
Phosphate (mg/l)	7.3	4.6
Nitrate (mg/l)	23.0	10.5

The physico-chemical analysis of the wastewater generated from the coffee processing plant has been given in Table 2. It was evident from this table that the wastewater was heavily polluted with organic load, nutrients and suspended matter. Organic load was measured in terms of COD and BOD and nutrients in the term of phosphate and nitrate. The values of temperature, pH, BOD, COD, suspended solids, phosphate and nitrate for upstream were 25 °C, 3.57, 14,200 mg/l, 25,600 mg/l, 5870 mg/l, 7.3 mg/l and 23.0 mg/ l, respectively, while for downstream these values were 22 °C, 4.45, 10,800 mg/l, 15,780 mg/l, 2080 mg/l, 4.6 mg/l and 10.5 mg/ l, respectively. On comparing these values with WHO permissible limits for discharging of treated effluent for irrigation purpose as given in Table 1, it was found that concentration of all these parameters were very high.

The physico-chemical characteristics of a nearby water stream have been given in Table 3. The values as depicted in this table for temperature, pH, BOD, COD, suspended solids, phosphate and nitrate for water before entering of the wastewater from this plant were 15 °C, 6.5, 120 mg/l, 176 mg/l, 520 mg/l, 2.3 mg/l and 4.0 mg/ l, respectively, while the values of these parameters for the sample taken from a point after entering of the wastewater from this plant were 18 °C, 5.15, 7800 mg/l, 9780 mg/l, 2880 mg/l, 4.10 mg/l and 7.5 mg/ l, respectively. After careful analysis of these parameters, it was found that the water quality of the stream before entering the effluent of coffee processing plant in this stream was quite good but not completely under permissible limits but the values of water samples of the stream taken from the point after discharging of wastewater from coffee processing plant were very high.

It was also found from this study that the people residing in the vicinity of this plant were utilizing this stream water for domestic purposes and were suffering from sever health problems. The seriousness of the situation could be predicted from Table 4 as it indicated that about 89% of the total surveyed population had spinning sensation and out of this 40% were children, 32% had eye irritation and out of that 25% were children and 40% were old persons, 85% skin irritation which was the common problem for the whole population studied, 42% stomach pain which was more prevalent among adult persons, 75% breathing problem which was more among the elder population and 25% of studied population suffered from nausea which was also common for the whole studied population. So, it was found, from this study, that some people were suffering from one problem while others were having cumulative health effects.

Table 3
Average values of the characteristics of nearby water bodies (river) before and after receiving coffee processing plant effluent, Zimma Zone, Ethiopia

Parameters	Water characteristics	
	Before	After
Temperature (°C)	15	18
pH	6.5	5.15
BOD (mg/l) (5 days at 20 °C)	120	7800
COD (mg/l)	176	9780
Total suspended solids (mg/l)	520	2880
Phosphate (mg/l)	2.3	4.1
Nitrate (mg/l)	4.0	7.5

Table 4
Survey report of the health impact on the community residing in the vicinity of coffee processing plant, Zimma Zone, Ethiopia

S. no.	Impacts	% Of population affected
1.	Spinning sensation (feeling drunk)	89
2.	Eye irritation (burning inside)	32
3.	Skin irritation	85
4.	Stomach problem	42
5.	Breathing problem	75
6.	Nausea	25

4. Conclusion

It is concluded from the physico-chemical analysis of the wastewater generated from coffee processing plant that all the parameters like pH, BOD, COD, total suspended solids, phosphate and nitrate were much more than the prescribed limits by WHO. This effluent is being directly discharged to the nearby waterbodies and thus causing many severe health problems like spinning sensation, eye, ear and skin irritation, stomach pain, nausea and breathing problem among the residents of nearby areas. So, there is a need to curb this problem through innovative and eco-friendly techniques.

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