Characterization of coffee pulp effluent for its pollution potential and nutrient potential and its impact on soil and water environment

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SUMMARY

The bio-chemical nature and nutrients content of coffee pulp effluent generated in the coffee pulping units of Hassan, Coorg and Chikamagalur districts of Karnataka and the impact of long term discharge on ground water quality and soil properties were studied in and around pulping units. The effluent was highly acidic in nature and had high soluble salts content, BOD, COD, suspended and dissolved solids. The effluent had more number of fungal and bacterial colonies and less number of actinomycetes population. The beneficial microbes like N-fixers and phosphate solubilizers were in substantial number but was low in major nutrients and high in micronutrients contents. The study on impact of long term discharge of coffee pulp effluent on soil health and near by surface or ground water quality indicated that available nutrients content of effluent discharged fields was slightly higher as compared to fields not receiving any effluent and has not polluted the near by water bodies.

Key words : Coffee pulp effluent, Bio-chemical nature, Nutrients, Water quality, Soil health.

In the era of globalization and industrialization, there is increasing demand for good quality produce and pollution free environment. On the contrary, many of the industries make use of large quantities of good quality water and discharge the entire quantity in the form of waste water with the objectionable odour, taste and harmful constituents which may pose threat to water and soil, the two most important natural resources which hold the key for our safe living.

The traditional coffee tract of India lies in Western Ghats which is the birth place of many rivers and rivulets, which traverse through coffee estates and are the lifeline of the people of not only that region but also plain area of many states. Pollution of soil and water bodies by the effluent discharged from coffee processing units is an environmental problem in all the countries which follow wet method of coffee processing, and India is not an exception. In India presently around 75 – 80 % of *arabica* and 10 – 15 % of *robusta* coffee is processed by wet method. In recent years, the processing of *robusta* coffee by wet method is on the increase due to growing demand for *robusta* parchment in international markets. In wet processing of coffee, water is used for conveying and separation of sound fruits from floats and dried berries, pulping of fruits, washing and soaking of parchment coffee. The problem of water pollution will be aggravated in coffee tracts because the processing period coincides with the dry season when the flow in natural water bodies will be at minimum level.

In the bio-diverse Western Ghats of Karnataka, coffee is being grown over decades and recently emphasis is being given to production of quality coffee by subjecting coffee fruits to pulping. In this process, a huge volume of pulp effluent is generated which is posing problems of disposal as it has high pollution potential. In contrast to this, the pulp effluent is a rich source of nutrients and organic matter (Anand Alwar, 1998) and hence can be used as a resource for growing crops during the lean season. In this context, an attempt has been made to characterize the pulp effluent in terms of its pollution potential and nutrient potential. Also extent of pollution of ground water and soil due to indiscriminate discharge of pulp effluent over years has been studied.

MATERIALS AND METHODS

Characterization of coffee pulp effluent:

Coffee pulp effluent samples were collected from 22 different pulping units in Hassan, Coorg and Chikamagalur districts of Karnataka state, India; at monthly intervals during the coffee processing season of 2003 - 04 (December to March). The effluent samples collected were analyzed for pH, EC, chlorides, carbonates, bicarbonates, suspended and dissolved solids, BOD and COD as well as major and micronutrients content by following

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standard procedures. The enumeration of total bacteria, fungi, actinomycetes, free living N-fixers and phosphate solubilizers in the effluent was carried out by following the standard dilution plate count technique.

Characterization of water and soil samples:

Indiscriminate discharge of effluents over the years might have resulted in pollution of water and soil. The effect of the effluent discharge over the years on quality of both the surface and ground water was assessed by collecting requisite number of water samples from near by water bodies such as ponds, open wells and bore wells at 1 - 2 km distance from the processing units. The suitability of water samples for irrigation was assessed as per the U.S.S.L. Staff (1954) classification of irrigation water, which is based on electrical conductivity and sodium adsorption ratio of the water samples.

A total of thirty surface soil samples (0 - 15 cm depth) were collected from Hassan, Coorg and Chikmagalur districts of Karnataka. Among these samples, fifteen were collected from fields which have different history of effluent application and rest from fields which have no history of effluent application and the impact of long term discharge of coffee pulp effluent on soil properties was studied by analyzing the samples for pH, EC, organic carbon and available major, secondary and micronutrients status.

RESULTS AND DISCUSSION

Chemical and biological nature of the effluent:

The coffee pulp effluent samples collected were analyzed for various parameters and compared with the standards prescribed by Indian Standard Institution (ISI) for discharge on soil or into water bodies (Table 1).

The values for different parameters varied among the effluents and within the effluent across the different months of pulping. The pH ranged from 3.37 to 4.29 with an average value of 3.90 and it was far below the ISI standards and highly acidic in reaction (Balakrishna Rao *et al*., 1977). The total soluble salts content of the effluent ranged from 0.278 to 4.589 dS m^{-1} with an average value of 1.714 dS m^{-1}. Total suspended and dissolved solids varied from 130 to 16,400 and 530 to 20,670 mg L^{-1}, respectively. The suspended and dissolved solids were well above ISI limits of 100 and 2,100 mg L^{-1} for suspended and dissolved solids, respectively during most of the times. The concentration of BOD and COD also varied at each time of collection and were above ISI limits of 30 and 250 mg L^{-1}, respectively (Hedaoo and Patil, 2003). The average values recorded were 13,784 and 25,912 mg L^{-1} for BOD and COD, respectively. These results are inconformity with those findings of Anand Alwar (1998). The variation in values for different parameters among the pulping units and within the effluent collected from a pulping unit during different months of pulping may be attributed to method adopted by the farmers, number of discs used in pulping machine, quantity of water used and also type of coffee fruit processed.

The coffee pulp effluent is poor in major nutrients content (N: 0.06; P: 0.003 and K: 0.045 %) but contains appreciable quantities of micronutrients (Fe: 17.17, Mn: 0.56, Zn: 0.51 and Cu: 1.57 ppm). The diversity of micro-organisms was noticed in the effluent. The effluent has more number of fungal (29.36) and bacterial (17.30) colonies but less number of actinomycetes population. The beneficial microbes like free living N-fixers and phosphate solubilizers were more in number (6.99 and 6.93, respectively). This might be attributed to high organic load in the effluent. More microbial activity was observed in paper and pulp mill effluent by Augustine *et al*. (2001).

Table 1: Characteristics of coffee pulp effluent

Chemical parameters	pH	EC (dS m^{-1})	SS (mg L^{-1})	DS (mg L^{-1})	BOD (mg L^{-1})		COD (mg L^{-1})	
Coffee pulp effluent	3.37- 4.29 (3.90)	0.278- 4.589 (1.714)	130-16,400 (4360)	530-20,670 (6350)	1,966-29,903 (13,784)		4,876-43,272 (25,912)	
ISI Standards	5.5 – 9.0	< 1.000	100	2,100	30		250	
Nutrients	Total N (%)	Total P (%)	Total K (%)		Micronutrients (ppm)			
					Fe	Mn	Cu	Zn
Coffee pulp effluent	0.0675	0.0032	0.0479		17.17	0.56	1.57	0.51
Biological parameters	Bacteria (CFU x 10^5)	Fungi (CFU x 10^4)	Actinomycetes (CFU x 10^3)		N-fixer (CFU x 10^3)		PSB (CFU x 10^4)	
Coffee pulp effluent	17.30	29.36	2.37		6.99		6.93	

Figures in parenthesis indicate average value of 57 samples collected from 22 different pulping units during different months of pulping

Fertility status of effluent discharged fields:

Fertility status of surface soil samples (0 - 15 cm depth) collected from farmer's fields that had different history of effluent application and had no history of effluent application has been given in Fig. 1. The results indicated that they were acidic in soil reaction. There was negligible difference in soil reaction between the soil samples collected from effluent discharged (6.09) and undischarged (6.04) fields. The total soluble salts content of soil was quite low in all the fields and it was more in soil samples collected from effluent discharged fields (0.32 dS m^{-1}) as compared to undischarged fields (0.15 dS m^{-1}). The organic carbon content of all the surface soil samples was quite high and it was more in soil samples collected from effluent discharged fields (2.47 %) as compared to effluent undischarged fields (2.23 %). The pH, EC and organic carbon content of soil increased with increase in the concentration of effluent added due to high organic load (Annadurai *et al*., 1999).

The available nitrogen content of soil was medium in both effluent discharged and undischarged fields whereas, available phosphorus and potassium content of soils were quite high irrespective of whether effluent was applied or not. There was no difference in the available phosphorus content (212 kg ha^{-1}) of soil between the samples collected from effluent discharged and undischarged fields. The available nitrogen and potassium were relatively higher in soil samples collected from effluent applied fields (473 and 975 kg ha^{-1}, respectively) than soil samples collected from effluent undischarged fields (413 and 548 kg ha^{-1}, respectively). This might be attributed to poor content of phosphorus in the coffee pulp effluent (Zalawadia and Raman, 1994 and Singh and Bahadur, 1997).

The exchangeable calcium and magnesium were found to be adequate in all fields. However, application of effluent decreased the exchangeable calcium and magnesium content of soil (Jadhav and Sawant, 1975). The available sulphur status of soil was high in both effluent discharged (35.79 ppm) and undischarged (32.91 ppm) fields (Fig. 1). The DTPA extractable micronutrients content of effluent discharged fields were higher except Cu than effluent undischarged fields. This might be due to high organic matter and micronutrients content in the

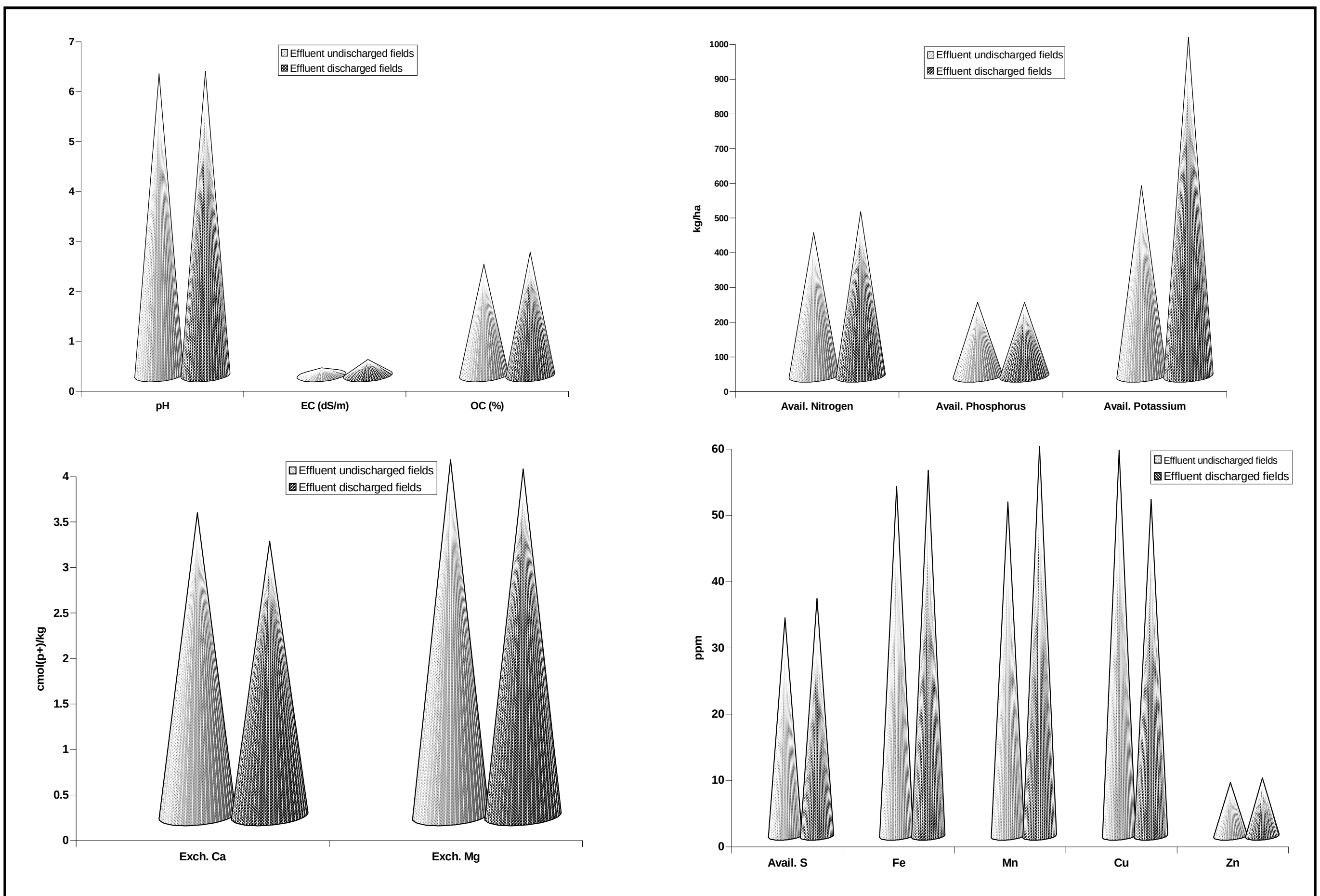

Fig. 1 : Physico-chemical properties of coffee pulp effluent discharged and undischarged fields

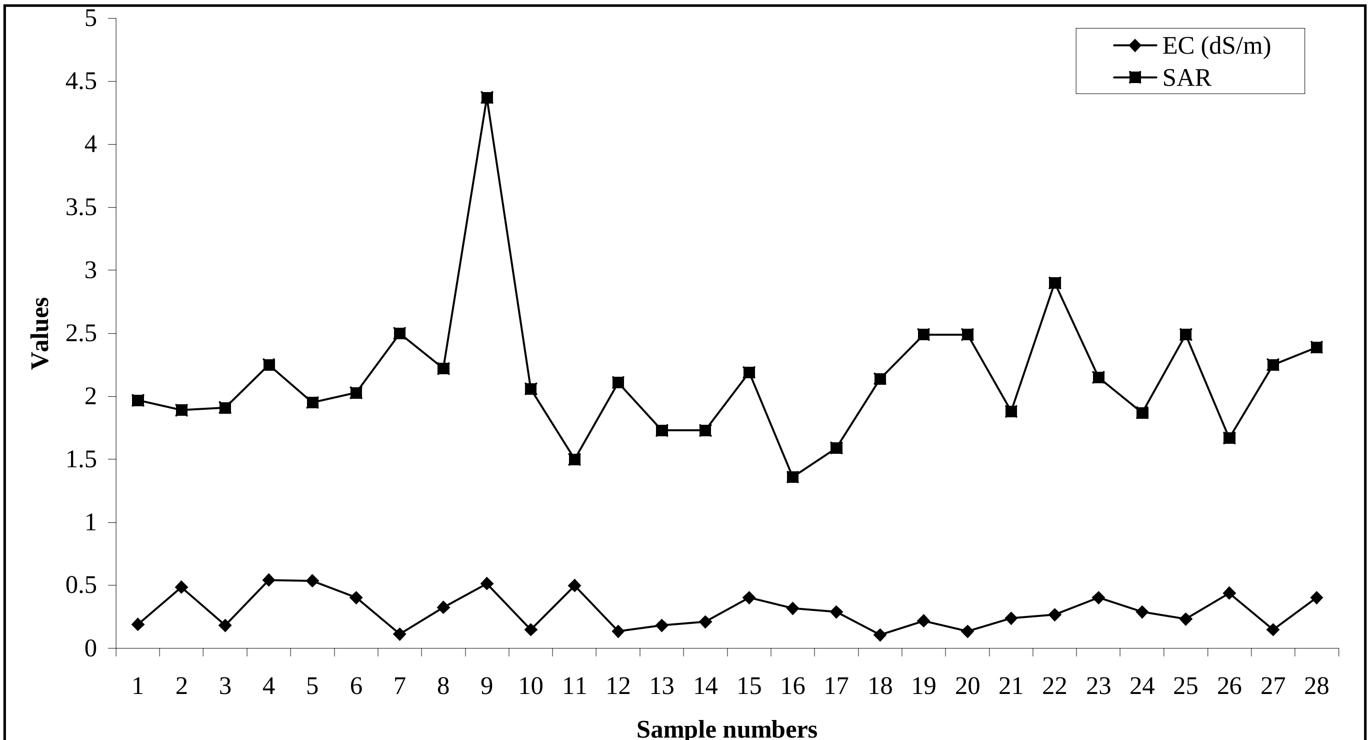

Fig. 2 : EC (dS/m) and SAR of water samples collected near the coffee pulping units of Hassan, Coorg and Chikamagalur districts

effluent (Zalawadia *et al*., 1997). Devarajan and Oblisami (1995) reported that the distillery spent wash application in rice increased the availability of N, P, K, Ca, Mg and micronutrients contents in soil besides increased the organic matter content of soil.

Water quality:

Indiscriminate discharge of effluent over the years might have resulted in pollution of ground water. However, analytical data on quality of water samples collected near the coffee pulping units (Table 2) indicated that most of water samples tested was neutral to alkaline in reaction and the values ranged from 7.10 to 8.50. The total soluble salts content was quite negligible and the values ranged from 0.11 to 0.54 dS m^{-1}. The bicarbonates and chlorides of water samples ranged from 1.50 to 10.50 and 0.95 to 2.32 mg L^{-1}, respectively. The suitability of ground water for irrigation was assessed as per the U.S.S.L. Staff (1954) classification of irrigation water. Among the ground water samples tested, 13 samples were in C_1S_1 class and remaining 15 samples were in C_2S_1 class (Fig. 2) and also indicated that water can be used for drinking purposes. This might be due to biodegradation and dilution / dispersion of the wastes (Baruah *et al*., 1993).

Conclusion:

The study indicated that coffee pulp effluent was highly acidic in nature and contained high suspended and dissolved solids with high BOD and COD values including diversity of microorganisms. This effluent is discharged indiscriminately on land or into water bodies may obviously affect the organisms living in them and pollute them. As adage goes "The real wealth of a nation is its Living Forests, Clean Rivers and Healthy Soils". Therefore, it is necessary to scientifically manage the wastes generated in an eco-friendly way by exploring their alternate uses. The available nutrients content of effluent discharged fields was slightly higher as compared fields not receiving any effluent and has not polluted near by water bodies.

Table 2: Characteristics of water samples collected near the coffee pulping units of Hassan, Coorg and Chikamagalur districts

Parameter	pH	EC	NO_3-N	Cl^-	CO_3^{2-}	HCO_3^-	Ca^{2+}	Mg^{2+}	Na^+	SAR
		(dS m^{-1})	(mg L^{-1})	(meq L^{-1})						
Water samples	7.1-8.5	0.11-0.54	0.58-13.97	0.95-2.32	Nil	1.5-10.5	0.39-3.72	1.37-8.82	2.14-7.13	1.4-4.4

Figures in parenthesis indicate average value of 28 samples

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