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Research Paper

Effect of Treated and Untreated Coffee Wastewater on Growth, Yield and Quality of Palmarosa Grass (*Cymbopogon martini* L.) var. motia.

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Abstract - *A study was carried out to characterize the coffee wastewater by measuring the selected physico-chemical characteristics, amelioration of the wastewater by using some ameliorative techniques and field study to know the effect of treated and untreated coffee wastewater on growth, yield and other properties of Palmarosa grass. The coffee wastewater is analyzed to know the physico chemical properties by using standard methodologies. Various ameliorative techniques were used to ameliorate the wastewater. The treated and untreated wastewater was used for crop growth and analysis. The results indicated that coffee wastewater is highly acidic and possess all the qualities of polluted water and the quality can be improved by different ameliorative techniques. The growth studies indicate that the treated effluent samples showed better results than the raw effluent (untreated). Among the different treated samples, sand cum clay filtered samples showed better results than other treatments. The raw effluent showed the inhibitory effect on grass growth, tillage formation, dry matter production, chlorophyll content and plant nutrients content. The study revealed that coffee wastewater can be successfully utilized for irrigation after suitable treatments and dilutions.*

Key words: Coffee Wastewater, Characterization, Amelioration, Inhibitory effect, Biochemical parameters, Plant nutrients etc.

Introduction

Water is one of the most important precious resource found on the earth. The water resources are most often affected by anthropogenic activities and also from industries. Pollution caused by human beings and industries is a serious concern throughout the world. Growth of population, massive urbanization, rapid rate of industrialization and modern techniques in agriculture have accelerated the water pollution and led to gradual deterioration of its quality.

India is one of the leading producers of good quality coffee since from decades, which is grown in southern states of India like Karnataka, Tamil Nadu and Kerala. In this zone, wet coffee processing method has been widely adopted. Wet coffee processing procedure requires mechanical removal of pulp with the help of water as a result of which it produces considerable amount of wastewater [7&18]. The water used for de-pulping of the coffee cherries is known as pulping water and it accounts for over half of the water used in this process [14]. The wastewater generated from coffee

processing has high concentration of organic pollutants [6] like pectin, proteins and sugars [13]. If done so, it will be very dangerous for the water bodies and human health. So, before its final disposal in water bodies, it needs a proper treatment.

The conventional wastewater treatment technologies being adopted in industrialized nations are quite expensive to build, operate and maintain. Moreover, to comply with stringent environmental regulations and for restoration of safe environment, it has become imperative to find less costly and easily adaptable treatment technologies for the wastewater.

Among the different treatment methods sand filtration and chemical coagulation were gaining importance nowadays. These are very simple to operate and less expensive in nature. The treated effluent samples which have amounts of beneficial plant nutrients, can be used as a source of irrigation for some crops.

The present study aimed to characterize the coffee wastewater, improving its quality through some amelioration techniques and to find out the impacts of treated and untreated CWW on growth, yield and plant nutrient content of Palmarosa grass.

Material and methods

Wastewater collection and characterization:

The Arabica Coffee Wastewater (CWW) samples were collected in dry plastic bottles which are rinsed with distilled water and then wastewater, from the coffee pulping and processing units of Chickmaglur district of Karnataka in the month of November and December 2010. The combined samples of wastewater were collected at the main drain pipe which is connected from washing tank to outside discharge unit. The physico-chemical properties like colour, odour, pH, EC, TSS, TDS, BOD, COD, N, P, K, Ca, Mg and S were analyzed according to the standard procedures. [11]

Amelioration of Coffee Wastewater (CWW):

For the amelioration of CWW, ameliorative techniques like sand, clay, sand+clay filtration and chemical coagulations were followed.

Sand, clay and sand + clay filtration: The CWW was passed through intermittent filters of sand, clay and sand + clay independently. The filtrate was collected and the samples were used for germination experiment [1].

Chemical coagulation: Two different chemicals were tried as coagulating agents such as potassium alum and lime. The coagulants were mixed with the wastewater and allow it for settle for 2 hours [7]. The supernatant solution was separated and used for analysis and germination experiments.

Experimental details:

Treatments	Treatment symbol
Control/ tap water	T_1
Raw coffee wastewater (CWW)	T_2
1:1 CWW + tap water	T_3
Sand filtered CWW	T_4
Clay filtered CWW	T_5
Sand + clay filtered CWW	T_6
Lime + CWW	T_7
Potash alum + CWW	T_8

Growth and yield studies:

The Plant height, number of tillers/clump, Leaf Area, Plant spread, leaf to stem ratio, green forage, dry matter production, chlorophyll content [2], total crude protein [3], total fiber [4] and plant nutrients content such as N, P, K, Ca, Mg and sulphur were analyzed by using the standard procedures.

Statistical analysis:

Fisher's method of analysis of variance was employed for the analysis and interpretation of the data. [12]. The level of significance used in 'F' test was P=0.05 and the CD values were calculated.

Results and Discussion

Physico chemical analysis of Coffee Wastewater (CWW):

The results of physico chemical analysis of Coffee Wastewater (CWW) is given in table 1. The results indicated that the coffee wastewater is dark brownish in color and having odour which is stringent and irritating in nature. It was evident that the wastewater was polluted with oxygen demanding waste besides dissolved and suspended matter. Organic load was presented in terms of high amount of BOD and COD. The wastewater also consists of high amount of TDS, TSS, and plant nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. The physico-chemical parameters were very high compared to their permissible limits to discharge for irrigation and horticultural uses as prescribed by ISI as shown in Table 1. This may be due to presence of large organic matter in the wastewater when the pure water is subjected to washing. The wastewater also consists of mucilage, pectin's and lignin's which also contribute to higher pollution load. [7]

The different ameliorative techniques improved the quality of wastewater by reducing the pollutants present in it [10].

Growth parameters:

The treated and untreated CWW samples were used to know their effect on growth, yield and quality of Palmarosa grass. The results were shown in table 2 and figure 1. The treatments showed significant difference between them. The highest growth, more number of tillers/ clump, highest leaf area and highest dry matter production were recorded in control (T_1) and in sand cum clay filtered CWW (T_6). This might be due to the presence of low concentration of toxic substances other pollutants. The least growth was recorded in raw coffee wastewater (T_2) which has huge amount of pollutants and may be due to osmotic pressure caused due to high dose. Osmotic pressure of the wastewater at higher concentration of total salts making imbibition was more difficult and retarded germination [5].

There is a significant difference between different treatments in green forage production (table 2& figure 1). Highest forage production was recorded in control (T_1) followed by sand cum clay filters (T_2). It might be due to increased plant performance under low pollutants concentrations. Reduction in green foliage yield in raw CWW (T_2) compared to other treatments due to decreased plant performance. Characters like plant height, number of tillers per clump, leaf area, dry matter content etc [9].

Biochemical parameters:

The treated CWW samples showed better results in biochemical parameters of Palmarosa grass which were given in table 3 and figure 2. The chlorophyll content of Palmarosa grass was recorded highest in tap water (T_1) followed by sand cum clay filtrate (T_6) and least chlorophyll content was recorded in raw CWW (T_2). The increased chlorophyll content might be due to the presence of Magnesium, which is the main constituent of chlorophyll. [8]

The treatments showed significant difference between them in total crude protein and crude fiber content in grass. Raw CWW (T_2) recorded the highest crude protein content, it might be due to additional supply of nitrogen through the wastewater. Nitrogen is the major component of amino acid which is the fundamental building units of proteins. [16 & 17],

Crude fiber content is highest in control (T_1) followed by sand cum clay filtrate (T_6). The fiber content is lowest, might be due to the presence of higher level of crude protein and time concentration of nitrogen in the grass. That had decreased the deposition of lignin and cellulose. The protein and fiber content in plant are normally inversely related. Increase in nitrogen resulted in decreased fiber quality. [17]

Plant nutrient status:

The treated wastewater samples showed better results in plant nutrient content after harvest. Highest nutrient content was recorded in control which is followed by sand cum clay filters (T_6) and the lowest concentration of plant nutrients were recorded in raw CWW (T_2). The results were showed in table 4 and figure 3. Highest plant nutrient concentration might be due to better plant performance in terms of plant growth and development [15].

Conclusion

Coffee pulping and processing industry, is one of the most important agro based industry in India, which uses enormous amount of fresh water for processing coffee and releases huge quantity of polluted water. The physico chemical analysis of wastewater revealed that the wastewater is highly polluted and the quality can be improved by suitable ameliorative techniques. The treated wastewater samples showed better results in terms of plant growth, dry matter production, green forage production, biochemical parameters and plant nutrient content. By the study it is revealed that coffee wastewater can be successfully used for irrigation after suitable treatments and proper dilutions.

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Table.1: Physico-chemical properties of Coffee Wastewater (CWW) compared with ISI standards

S. No.	Parameters	Values	ISI tolerance limits
General parameters			
1	Colour	Dark brownish	Clear
2	Odour	Stringent and irritating	Odourless
3	pH	3.96	5.5-9.0
4	EC(dSm-1)	1.85	<1.00
5	Total solids (mg/l)	16.07	2200
6	Dissolved solids (mg/l)	8.13	2100
7	Suspended solids (mg/l)	7.93	100
8	BOD (mg/l)	14119.00	30
9	COD (mg/l)	29550.00	250
Chemical parameters			
10	Chloride (meq/l)	6.45	-
11	Bicarbonate	7.92	-
12	Total nitrogen (mg/l)	8.30	100
13	Total phosphorus (mg/l)	0.40	-
14	Total potassium (mg/l)	5.60	-
15	Iron (ppm)	23.03	-
16	Zinc (ppm)	0.89	-
17	Copper (ppm)	1.86	-
18	Manganeese (ppm)	0.87	-

All parameters were expressed in mg/l except temperature, pH, EC, colour and odour.
ISI-Indian Standard Institute

Table. 2: Effect of treated and untreated coffee wastewater (CWW) on growth parameters of Palmarosa grass at harvest

Treatments	Plant parameters						
	Plant height (cm)	**Number of tillers**	**Leaf Area (cm^2/plant)**	**Plant Spread (cm^2)**	**Dry matter production (gm/plant)**	**Leaf to stem ratio**	**Green forage production (tonne/ha)**
T_1: Control/tap water	114.36	20	4798.53	14713.06	114.97	1.36	22.08
T_2: Raw Coffee Wastewater	92.60	14	2570.46	12946.46	78.20	1.10	15.38
T_3 : 1:1 CWW + tap water	98.30	15	3217.53	13347.35	98.53	1.20	17.93
T_4 : Sand filtered CWW	108.20	19	4234.36	14542.43	117.90	1.36	19.75
T_5 : Clay filtered CWW)	105.50	22	4212.16	13933.33	106.13	1.23	19.20
T_6 : Sand + clay filtered CWW	110.60	18	4280.33	14350.66	121.46	1.27	19.65
T_7 : Lime + CWW	96.20	17	3931.96	13949.00	101.10	1.25	18.87
T_8 : potash alum + CWW	94.96	16	3805.73	13829.66	100.53	1.19	18.13
F Value	*	*	*	*	*	*	*
CV (%)	1.08	2.59	1.18	1.69	0.65	1.28	2.83
S. Em ±	0.64	0.26	24.43	1.38	0.40	0.01	0.31
CD @ 5%	1.94	0.80	80.37	4.19	1.20	0.03	0.93

NOTE: *Significant at 5%

Table. 3: Effect of treated and untreated Coffee Wastewater (CWW) on chlorophyll content, crude protein and crude fiber content Palmarosa grass.

Treatments	Total chlorophyll (mg/g fw)	Total crude protein (%)	Total crude fiber (%)
T_1: Control/tap water	2.846	5.521	28.938
T_2: Raw Coffee Wastewater	2.043	10.673	24.300
T_3 : 1:1 CWW + tap water	2.476	7.190	26.010
T_4 : Sand filtered CWW	2.716	5.466	27.510
T_5 : Clay filtered CWW	2.670	5.890	29.100
T_6 : Soil + clay filtered CWW	2.813	6.290	29.480
T_7 : Lime + CWW	2.616	6.160	27.160
T_8 : potash alum + CWW	2.573	6.330	24.600
F Value	*	*	*
CV (%)	1.409	3.171	1.298
S. Em ±	0.021	0.123	0.204
CD @ 5%	0.064	0.372	0.618

NOTE: *significant at 5%

Table. 4: Effect of treated and untreated coffee wastewater (CWW) on plant nutrient content (%) of Palmarosa grass after harvest

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Sulphur (%)
T_1: control/tap water	1.060	0.430	1.510	0.234	0.349	0.169
T_2: Raw Coffee Wastewater	1.493	0.210	1.228	0.219	0.231	0.150
T_3 :1:1 CWW + tap water	1.060	0.173	1.248	0.239	0.314	0.130
T_4 : Sand filtered CWW	1.157	0.213	1.288	0.210	0.321	0.150
T_5 : Clay filtered CWW	1.126	0.230	1.246	0.202	0.339	0.160
T_6 : Soil + clay filtered CWW	1.040	0.263	1.256	0.220	0.331	0.174
T_7 : Lime + CWW	1.440	0.163	1.367	0.260	0.270	0.140
T_8 : potash alum + CWW	0.996	0.130	1.206	0.270	0.206	0.121
F Value	*	*	*	*	*	*
CV (%)	2.183	6.467	1.444	3.734	1.954	0.768
S. Em ±	0.014	0.007	0.010	0.005	0.003	0.001
CD @ 5%	0.043	0.022	0.032	0.015	0.010	0.002

NOTE: *significant at 5%

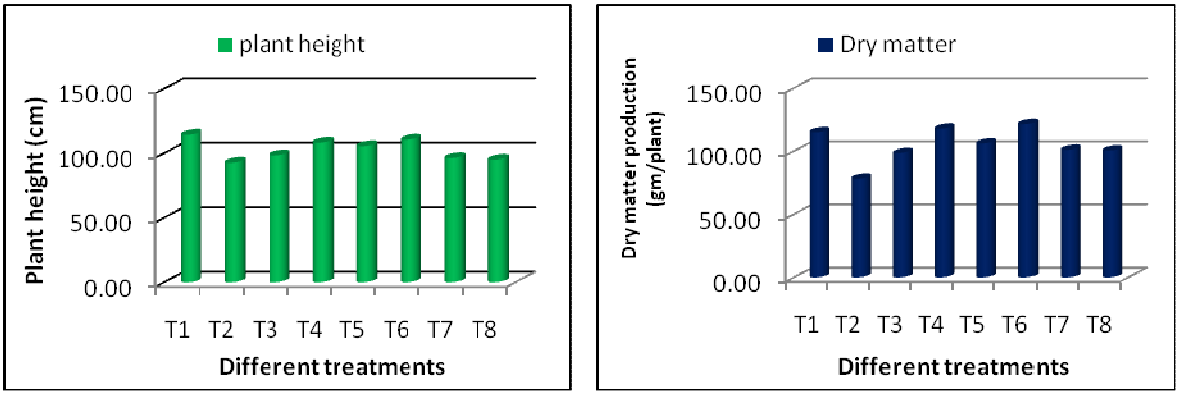

Fig. 1: Effect of treated and untreated Coffee Wastewater on plant height and Dry matter content of Palmarosa grass at harvest

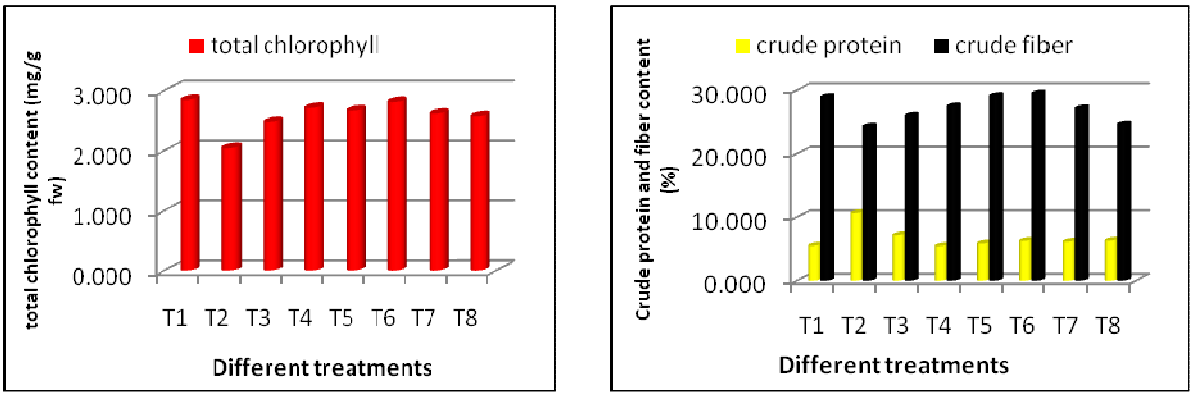

Fig. 2: Effect of treated and untreated Coffee Wastewater on chlorophyll and crude protein and fiber content of Palmarosa grass.

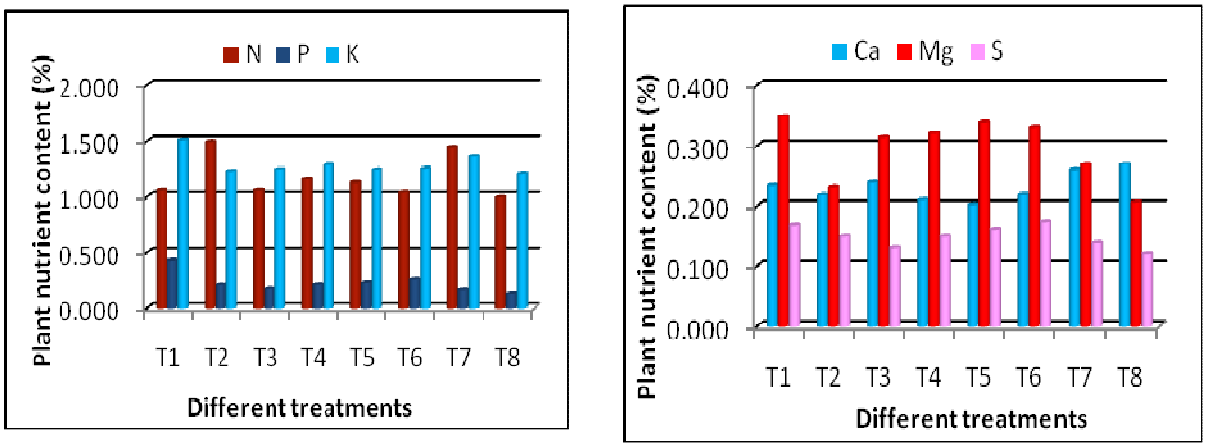

Fig. 3: Effect of treated and untreated Coffee Wastewater on plant nutrient content of Palmarosa grass after harvest