Original Article

Bioremediation of Coffee Pulping Waste-Water : An Anlytical Study

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ABSTRACT

Wastewaters from Coffee pulping are high in organic loadings and exhibit high acidity. The untreated effluents from coffee processing greatly exceed the self purification capacity of natural waterways. Therefore, in the present study Effective Microorganisms were used bioremediation of Coffee pulping wastewater. Firstly, the amount of sedimentable solids contributing to Chemical Oxygen Demand (COD) loading of waste water was lowered. This was achieved during a sufficient time of acidification of sugars present in the waste water. After full acidification, the clear, acid wastewater was treated by natural limestone to lift the pH from around 4 pH to a pH to around 6. Further, at this pH levels, upward aerobic sludge tank digestion with use of Effective Microorganisms was carried out. The secondary treatment and consumption of phosphates was accomplished in a locally adopted constructed wetland using macrophytes. The wastewater tertiary clean up and dilution of Biological Oxygen Demand (BOD) loadings was achieved by leading waste waters through a pond of water hyacinths. Finally, after this multi step clean up, water was safe to release into natural waterways or for reuse for irrigation purposes.

Keywords: coffee pulping; BOD; effective microorganisms; DO; COD; eutrophication.

INTRODUCTION

Coffee is a major commercial crop in India. In India, about 3 Lakh tones of coffee is grown annually and India is ranked sixth in the world in coffee production [1]. Karnataka is the largest coffee growing and coffee pulping state in India accounting for about 72% of total coffee produced. More than 3000 coffee estates located in the districts of Chikkamagalur, Kodagu, Hassan and Mysore carry out pulping (wet processing that needs huge quantities of water as well as discharge equally large quantities of wastewater). It is estimated that nearly half the coffee grown here (40 to 50%) is processed by wet pulping method to yield a 'superior' quality product. However, wet processing produces a Biological Oxygen Demand (BOD)/Chemical Oxygen Demand (COD) rich effluent. The coffee wastewater is rich in simple organic matter such as sugars, pectin and primary cell walls released during the pulping process and washing. A significant part of the wastewater enters the riverine systems while an equally large quantity is held in man-made and natural water tanks posing a serious water pollution threat. It is estimated that every tonne of coffee produced releases 80,000 litres of wastewater. The One kilogram of dried coffee produces around 2.5 kg of wet pulp and 12.4 kg of effluent with a BOD of 1000 mg/ L[2]. At present wastewater generated from coffee pulping is let into small lagoons and are operated only during the coffee pulping season. These lagoons often fail and sometimes get overloaded with accumulation of volatile fatty acids and become malodorous, causing potential hazards to ground and surface water resources[3]. The partially treated coffee wastewater containing sugars and sugar derivatives (sucrose, fructose and pectin), when let into the water bodies during lean flow /low storage periods results in rapid eutrophication and pose a great danger to the receiving waters. In Karnataka state, the coffee pulping wastewater is disposed into unlined Kutcha pits and major disadvantages associated with it are odour problems, mosquito breeding (public health issues), and low loading rates, unsatisfactory treatment

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and loss of cultivable area. Sometimes the problem is so severe that in many towns downstream, drinking water pumped from natural tanks possesses a deep purple shade - characteristic of partly treated coffee effluents reaching these water bodies. Thus, the present study was carried out to make the coffee pulping wastewater suitable for let out in to river systems with the use of Effective Microorganisms and Macrophytes. The study was aimed at reducing the BOD of coffee pulping wastewater and increasing the DO level in the Wastewater.

MATERIALS AND METHODS

Collection of Coffee Pulping Wastewater : The experimental treatment procedures for Coffee Pulping Wastewater were done throughout the dry period of the year (November to March) at Baganeheddal Estate, Chickmangalore. At the end of each steps, the samples were collected and analysed for BOD, COD, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) at Regional Pollution Control Board, Hassan and Veterinary College, Hassan.

Steps in Coffee Pulping Wastewater Treatment : The treatment system consisted of an acidification pond, followed by a neutralization tank filled with ground limestone. After neutralization of waste water to pH 8 to 10, water was treated with effective microorganisms (EM) for degradation of organic matter in an aerobic sludge tank before entering into wetland planted with macrophytes for secondary treatment. For tertiary treatment, waste water was made to run through a water hyacinth pond for water polishing before entering the open waterway. In the acidification pond, effluent (pulping, pre-sorting, and washing) water was allowed to rest at shallow depths for at least 6 hours.

The acidity of acid water was lifted to pH 8 to 10 using low cost of natural limestone (CaCO3). About 250 milligrams of limestone was added to buffer 1 litre of acid water[4].

$$2CH_3COOH + CaCO_3 = Ca\ (CH3\ CO_2)2 + CO_2 + H_2O$$

During primary water treatment, special strains of Effective Microorganisms (EM) from coffee plantation soils were used as feedstock. In the process of aerobic decomposition, bacteria metabolized dissociated acetate ions.

$$2CH_3COOH = 2CH_4 + 2CO_2$$

Secondary treatment was done in a wetland planted with rushes and reeds (Phragmitis australis) following the design of an emergent macrophyte treatment system with subsurface flow[5]. Tertiary treatment and final cleanup was done in water hyacinth (*Eichornia crassipes*) ponds. Finally treated water was let into water bodies or reused for pulping process or used for irrigating the plantations. The results were analyzed by Student's T test.

RESULTS

The treatment system consisted of an acidification pond, wherein effluent (pulping, pre-sorting, and washing) water was allowed to rest at shallow depths for at least 6 hours. During this time, raw mucilage came out of solution and floated on top which was raked off. The acidity of acid water was lifted to pH 8 to 10 using natural limestone (CaCO3). In the presence of limestone, the acetic acid gets converted to calcium acetate with a radical change in solution pH from 3.8 up to 8. In the primary water treatment, special strains of Effective Microorganisms (EM) from coffee plantation soils were active at a pH of around 6 at ambient temperatures. In the process of aerobic decomposition, bacteria metabolized dissociated acetate ions. During aerobic operation, a reduction of 70 to 90% of BOD content was achieved in as little as 4-6 hours retention time. In the secondary emergent macrophytes treatment system, a dissolved oxygen level in the water was increased through diffusion of oxygen in the root zone of the macrophytes growing in the flooded gravel bed. The additional oxygen supplied speeded up the aerobic decomposition of remaining organic matter. The construction of wetland was able to remove between 49 and 81% BOD loadings and lowered the amount of suspended solids between 36 and 70% depending on initial BOD loadings and retention time[6]. In the Tertiary treatment and final cleanup Water Hyacinth was particularly active in the removal of both bacteria and heavy metals.

Table 1: Shows the Physico-Chemical characteristics of Coffee pulp waste-water at different steps of treatment

Sampling steps Parameters	Untreated Coffee pulp wastewater	Neutralised Coffee pulp wastewater	EM treated Coffee pulp wastewater	Secondary treatment	Tertiary treatment
pH	5.39	10.23	7.30	7.1	7.26
COD (mg/L)	-	-	-	-	3480
BOD (mg/L)	8700	8045	6320	2600	2025
TDS (mg/L)	4068	11634	12594	3726	4876
TSS (mg/L)	5254	4892	10440	3208	798

Fig 1. Different stages in treatment of Coffee pulping wastewater

1

2

3

4

DISCUSSION

The attempts made by the previous researchers to treat coffee processing wastewater using biological methods included mesophilic and thermophilic digestion of instant coffee wastewater[7], use of UASB reactor at mesophilic and thermophilic conditions[8], using anaerobic hybrid reactor (UASB/Filter), anaerobic digestion in multi feed bioreactor[3]. The review of the literature suggested that anaerobic digestion of coffee pulping wastewater is possible but long term stability is an operational

problem. Application of advanced oxidation processes on treatment of coffee processing wastewater was very meager. Review of the earlier studies revealed treatment of coffee processing wastewater by chemical coagulation-flocculation and advanced oxidation processes[9], decolorization of synthetic coffee effluent[10], using solar Photo-Fenton reaction and decolorization of UV assisted Photo-Fenton for model coffee effluent[11]. Also, attempts with two consecutive experiments have been conducted to evaluate the effect of "Effective Microorganism (EM)" on the nutritive value of coffee pulp/husk. The results obtained showed that the best silages were prepared by ensiling pure coffee pulp/husk and chopped grass hay in combination with 30% coffee pulp/husk with the use of EM as measured by visual appraisal and pH value. Also there was significant reduction ($P<0.001$) in the anti-nutritional factors content (lignin, caffeine and condensed tannin) of pure coffee pulp and husk ensiled with the use of effective microorganisms (EM)[12]. The microorganisms coexist and act synergistically when applied. They decompose organic compounds and produce various low-molecular organic compounds, such as amino acids, sugars, vitamins, enzymes, and other bioactive substance[13]. The unique property of EM technology is that all the microorganisms work together to devour toxic compounds caused by human pollution. The effective microorganisms represent two dynamic and opposing forces (forces of degeneration and regeneration) existing within nature, since EM is a mixture of regenerative microorganisms naturally adapted to consume degenerative ones. The more holistic approach of EM technology is that it effectively cultivates beneficial microorganisms to a level at which pathogenic and destructive bacteria cannot proliferate. This in turn reduces biological stress on virtually every environment where EM is used such as improving soil structure, purifying wastewater or anti-oxidizing the cells of the human body[14]. The EM was first developed to make the agricultural sector free from the side effect of large scale commercial fertilizer. The first concept of using EM in environmental management was used in the process of composting crop residues and animal wastes aimed at producing bio-fertilizer[15,16]. The EM was also effectively used in purification and re-use of urban water sewerage for the use of garden and toilets[14].

CONCLUSION

The Effective Microorganisms technology was central in the treatment process as the highest reduction of BOD levels in relatively short times was achieved. Finally, after the multi step clean up procedure, water was safe to release into natural waterways or for irrigation purposes. However, the large scale validation of the technique is essential before practical implementation at filed levels.

Conflict of interest : declared none.

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