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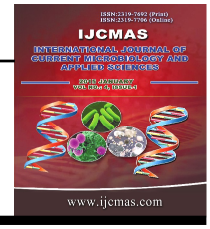

Original Research Article

Treatment of coffee effluent by – *Moringa oleifera* seed

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A B S T R A C T

Coffee is one of the world's most popular and widely consumed beverages. It has been estimated that 40–45 L of waste water is produced per kilogram of coffee processed. The waste water coming out of coffee industries has high concentration of organic pollutants and is very harmful for surrounding water bodies, human health and aquatic life if discharged directly into the surface waters. Hence it is essential to treat and manage the coffee waste. An attempt was made in this study to use *Moringa oleifera* seed as a means to treat the coffee effluent. The coffee effluent was collected from Bodimetu, Theni thaluka, Tamil Nadu and its physicochemical characters were analysed by standard methods. Its microbial load was also analysed by standard methods. Before treatment the sample was undesirable in its physicochemical and biological properties. Coffee effluent treated with *Moringa oleifera* seed altered the physicochemical properties and reduced the microbial load also.

Introduction

Coffee is one of the most important agricultural commodities in the world. It belongs to the family Rubiaceae and it has many species. *Coffea arabica* and *Coffea robusta* are the two principal varieties of the genus cultivated all over the world for commercial purpose (ICO, 1998). The total world production of coffee waste was estimated to be about 22 million metric tons coffee pulp, 2.4 million metric ton mucilage and 8.6 million metric ton hull (FAO, 1997). The processing steps in coffee may be grouped into primary, secondary and tertiary steps. Primary processing is done in two major ways - the dry and wet methods (www.ico.org). In secondary processing the dried green beans are subjected to mechanical removal of the parchment layer from the bean. The beans are then graded according to size, shape, weight, colour and uniformity. In tertiary processing coffee powder may be subjected to different processes to develop product varieties. Instant coffee and decaffeinated coffee are two main products from tertiary treatment steps (Dinsdale *et al.*, 1996, 1997; Fernandez and Forster, 1994; Kostenberg and Marchaim, 1993).

The coffee industry uses large quantities of water during the various stages of the production process. Consequently, the amount of waste water comes out from the industry is high. It has been estimated that 40–45 L of waste water is produced per kilogram of coffee (Rodriguez *et al.,* 2000). The waste water from coffee industries has high concentration of organic pollutants (Chapman, 1996; De Matos *et al.,* 2001; INEP, 2001; MoEF, 2003) and is very harmful for surrounding water bodies, human health and aquatic life if discharged directly into the surface waters (Deepa *et al.,* 2002; Enden and Calvert, 2002). This effluent is being directly discharged to the nearby water bodies 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.

Treatments applied to coffee pulp consisted of alkali treatment; a combined acid–alkali, and combined alkali-ensilage treatment (Ulloa Rojas *et al.,* 2002), aerobic digestion and anaerobic digestion is the degradation of complex organic matters under the absence of oxygen. This process is time consuming as bacterial consortia responsible for the degradation process requires time to adapt to the new environment before they start to consume on organic matters to grow (Gerardi, 2003).

Aerobic treatment, membrane treatment system and evaporation method are the currently available alternative methods for palm oil mill effluent (POME) treatment (Gopal and Ma, 1986). Treatments applied to coffee pulp (CoP) consisted of alkali treatment, a combined acid–alkali and a combined alkali-ensilage treatment (Murillo, 1979). These methods have their own merits and demerits.

So, there is a need to solve this problem through innovative and eco-friendly techniques (Alemayehu Haddis and Rani Devi, 2008). Having known the problems of coffee waste and its management an attempt was made in this study to use bioproducts as a means for ecofriendly coffee waste management. *Moringa oleifera* seed was chosen to treat the coffee effluent. Seeds from *Moringa oleifera* have been recommended for water treatment in Africa and south Asian countries (APHA, 1998). According to Jojn (1998), the seeds of *Moringa* family are very efficient water coagulants and they are non toxic (Gottsch, 1992). *M. oleifera* seeds also act as antimicrobial agent against variety of bacteria and fungi (Madsen *et al.,* 1987). Indian Traditional Siddha Medicine also mentions about various methods to purify drinking water. One of the claims is that the water treated with the seed of *Moringa oleifera* become safe for drinking and healthy living (Durairasan, 1999).

Materials and Methods

Ten liters of coffee effluent was collected from Bodimetu, Thenithaluka, Tamil Nadu. The effluent was collected from selected site in polythene bottles and was kept in room temperature till use. The samples were collected in the month of January, 2013. The samples were immediately brought to the laboratory to assess various physicochemical and biological characters. Temperature and pH of the effluent were recorded at the time of sample collection, by using thermometer and pocket digital pH meter respectively. Other parameters such as hardness, chlorides, alkalinity and nitrate were estimated in the laboratory by standard methods as prescribed in APHA (1998). Biological characteristics of the collected coffee effluent were analyzed as per standard methods.

Preparation of plant material

Good quality dried *Moringa oleifera* (drumstick) seeds were collected from local shop, Tiruchirappalli. Seeds were cleaned and dried under shade. The wings and coat from the seeds were removed and the remaining pat alone was powered using mortar and pestle and this powder was stored in air tight container and this was used for further study.

Treatment with *Moringa oleifera*

Coffee effluent sample collected from Bodimetu, Theni thaluka, Tamil Nadu was subjected to treatment with *Moringa oleifera* powder. Treatment was given directly to the waste water by using *Moringa oleifera* seed powder at a concentration of 50g/L and the treatment is for a period of a month. The physicochemical and biological parameters were checked before and after treatment for 36 days at 7 days interval.

Result and Discussion

The results revealed that the colour of the coffee effluent was dark brown before treatment, but after treatment with *Moringa oleifera* the colour became light greenish brown. Fruity taste and unpleasant odour was changed to bitter and pleasant after treatment. The temperature and pH of the coffee effluent remained same before and after treatment (Table 1). Initial alkaline pH was changed to acidity after treatment.

As far as the chemical parameters analysed, expect acidity the rest of them were reduced gradually after treatment with *Moringa oleifera* seed power (Table 2).

Before treatment the coffee effluent had innumerable number of bacterial colonies but after treatment with plant material the number of bacteria got reduced. At the end of 36th day there is no bacterial colony at all (Table 3).

Colour is very a important factor for aquatic life for making food from sun rays. The photosynthetic activity is found to be reduced due to dark coloration. Dark colour will affect other parameters like temperature, DO and BOD (Siddiqui and Waseem, 2012). In this study coffee effluent was dark brown in colour before treatment and when *Moringa oleifera* seed power was added it become greenish in colour and remained same even after 36th days. The reason could be the colour of the seed powder.

Odour of water is caused both by chemical agents like hydrogen sulphide, free chlorine, ammonia, phenols, alcohols, esters, hydrocarbons and biological agents such as algae, fungi and other microorganisms (Sharma, 2000). Here the odour of the effluent was unpleasant initially and after treatment it was pleasant. It could be due to the phytochemicals of the seed power.

pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity (Gupta, 2009). The reduced rate of photosynthetic activity, the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH. Interestingly the temperature of the coffee effluent remained same before and after treatment and the pH became acidic. It could be due to the action between the chemical of *Moringa oleifera* seed power and the organic matter of the effluent.

All physiological activities and life processes of aquatic organisms are generally influenced by water temperature (Murhekar Gopal Krushna, 2011). It is an important parameter because it affects the biochemical reactions in aquatic organisms.

Alkalinity acts as a stabilizer for pH. Alkalinity, pH and hardness affect the toxicity of many substances in the water. It is determined by simple dilHCl titration in presence of phenolphthalein and methyl orange indicators (Patil *et al.*, 2012). Here the alkalinity got reduced gradually after treatment and it was reflected in pH. But acidity was increased gradually. Acidity is a measure of the effects of combination of compounds and conditions in water. It is the power of water to neutralize OH- and is expressed in terms of CaCO3. Water attains acidity from industrial effluents, municipal waste (drainage) and from humic acid (Kalshetty *et al.*, 2014).

There was a gradual reduction in total hardness, magnesium, calcium, chloride indicating that the chemical constituent of *Moringa oleifera* seed changed the content of salts present in the coffee effluent and converted the effluent soft. Hardness, especially with the presence of magnesium sulphate can lead to the development of laxative effect on new consumers and cause scaling in pipelines.

Calcium salts tend to cause incrustations on cooking utensils and water heaters. Hence it is essential to soften the portable water (Spellman, 2003). Chloride is a common constituent of all natural water and is generally not classified as harmful constituent (Chutia and Sarma, 2009) and it is the indicator of contamination with animal and human waste.

More than 50% reduction of DO, COD and BOD was observed in this study which may be due to the action of phytoconstituents of *Moringa oleifera* and on coffee effluent. DO is very important for all physical and biological process going in water. The DO levels in waters depend on physical, chemical and biological activities of the water body. The analysis of DO is very important in water pollution and waste water analysis (Yadav Anoop and Daulta Renu, 2014). Biological oxygen demand is the measure of oxygen required by microorganisms whilst breaking down organic matter. BOD is used as the index of organic pollution of waste water that can be decomposed by bacteria under anaerobic conditions (Mane, 2013). COD determines the oxygen required for the chemical oxidation of organic matter. COD values conveyed the amount of dissolved oxidizable organic matter including non-biodegradable matter present in it (Kalshetty *et al.*, 2014).

Microbiologically the results revealed that the bacterial load was reduced after treatment with *Moringa oleifera* and after 36th day there was no bacteria at all indicating that *Moringa oleifera* has antimicrobial activity. The reduction observed in the bacterial population of water treated with *Moringa oleifera* seed can be attributed by the antibacterial properties of the bioactive ingredient (Olayemi and Alabi 1994).

Narashima Rao *et al.* (1984), recorded similar observations with a component of pterygospermin present in flower. A number of bioactive agents that have been isolated from different parts of the *Moringa oleifera* may account for the reduction of microbial load (Olayemi and Alabi 1994).

It is concluded from the physicochemical analysis of the coffee effluent generated from coffee processing plant that all the parameter like temperature, total hardness, BOD,COD were much more than the prescribed limits. *Moringa oleifera* was effective in the removal of chemical impurities from the effluent. Likewise, *Moringa oleifera* was effective in the inhibition of bacterial contamination. Since, the natural products are of low cost and are easily available they can be used to treat the waste water. From this study it can be concluded that the *Moringa oleifera* treatment is suitable for the removal of chemical impurities and microbial contaminations like bacteria of coffee effluent.

Table.1 Physical characters of coffee effluent

S.No	Parameters analysed	Physical characters before treatment	Physical characters after treatment with *Moringa oleifera*					
			1st day	8th day	15th day	22nd day	29th day	36th day
1	Colour	Dark brown	Light greenish brown	Light greenish brown	Light greenish brown	Light greenish brown	Light greenish brown	Light greenish brown
2	Taste	Fruity, Ripe	Bitter	Bitter	Bitter	Bitter	Bitter	Bitter
3	Odour	Unpleasant	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant
4	Temp.	35^{o}C	35^{o}C	35^{o}C	35^{o}C	35^{o}C	35^{o}C	35^{o}C
5	pH	9	9	8.8	8.5	7.5	7	6.8

Table.2 Chemical characters of coffee effluent

S.No	Parameters analysed	Chemical characters before treatment	Chemical characters after treatment with *Moringaoleifera*					
			1st day	8th day	15th day	22nd day	29th day	36th day
1	Total Alkalinity	10mg/l	10mg/l	8mg/l	6mg/l	4mg/l	3mg/l	3mg/l
2	Total acidity	9 mg/l	9 mg/l	12 mg/l	15 mg/l	19 mg/l	22 mg/l	25 mg/l
3	Total Hardness	90 mg/l	85 mg/l	65 mg/l	60 mg/l	51 mg/l	40 mg/l	35 mg/l
4	Total Calcium	80 mg/l	74 mg/l	60 mg/l	55 mg/l	40 mg/l	34 mg/l	29 mg/l
5	Estimation of Magnesium	10 mg/l	10 mg/l	9 mg/l	8 mg/l	7 mg/l	5 mg/l	4 mg/l
6	Estimation of Chloride	60 mg/l	56 mg/l	45 mg/l	34 mg/l	29 mg/l	20 mg/l	16 mg/l
7	Dissolved oxygen	15 mg/l	15 mg/l	11 mg/l	10 mg/l	8 mg/l	7 mg/l	5 mg/l
8	BOD	14 mg/l	12 mg/l	10 mg/l	9 mg/l	7 mg/l	5 mg/l	4 mg/l
9	COD	14 mg/l	12 mg/l	11 mg/l	8 mg/l	8 mg/l	7 mg/l	6 mg/l

Table.3 Biological population of coffee effluent

S.No	Sample Code	Before treatment	Duration and microbial load after treatment (No. of colony)					
			1st day	8th day	15th day	22nd day	29th day	36th day
1	CE	Innumerable	25	16	9	5	-	-

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