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Research Article

WATER QUALITY MODELING TO PREDICT IMPACT OF COFFEE PULPING WASTEWATER ON RIVER CAUVERY

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Key words: Mathematical model, MULTMIX, Chemical oxygen demand, Biological oxygen demand, Dissolved oxygen, Pollutants.

ABSTRACT

In the current review an attempt has been made to anticipate the influence of coffee pulping wastewater dumping into the river Cauvery. The coffee pulping wastewater is a high strength complex wastewater characterized by low pH with high COD, ammonia nitrogen, nitrate nitrogen and phosphorus causing rapid decrease of Dissolved Oxygen (DO) after its disposal to any natural water body. Thus, impactfrom the disposal of raw coffee pulping wastewater on DO level in river Cauvery has been predicted using MULTMIX programme. MULTMIX model was used to predict the combined impact of two outfalls. In the treatability study of coffee pulping wastewater Electrocoagulation (EC) treatment and Electrocoagulation Anaerobic Sequencing Batch Reactor (EC+ASBR) coupled treatment was chosen with an aim to reduce the Biochemical Oxygen Demand (BOD) upto 80%. Treated wastewater characteristics done using laboratory scale reactor, was input for the model, and thus the optimal BOD to maintain permissible DO in the river was predicted. Based on the results obtained, this study presents suitable treatment method for treating coffee pulping wastewater which can be further disposed to the water bodies which will reduce impact in terms of river water pollution. Using mathematical models the carrying capacity of the river Cauvery was determined to mitigate the pollution load from coffee processing units.

INTRODUCTION

Agricultural activities are polluting the water streams in and around Coorg, Chikkamagalur and Hassan. This forms a serious threat to a reliable drinking water supply for the towns located on river banks. Coffee is a commercially planted crop, grown in environmentally susceptible environment like Western Ghats. Coffee pulping as well as processing enterprises dump coffee pulp, husk as well as effluents presenting environmental dangers to water and land value surrounding such coffee processing operations. Presence of hazardous substances like phenols among these by-products limitations the direct employment of coffee effluents for agriculture (Preethu, et al., 2007). The major pollutant is the processing of coffee beans that produces wastewater of high concentrations of organic matter and nutrients, depleting dissolved oxygen in the water. From literatures, it is found that the coffee pulping wastewater is very harmful to the receiving water bodies. The present treatment technologies adopted for treating coffee pulping wastewater are expensive to install, operate and maintain (Asha, et al., 2021). Hence it is necessary to find a treatment technology to conform to the stringent environmental regulations to restore the environment.

River Water Quality Modeling

The coffee pulping units in Coorg and Chikkamagalur are located near valleys and many of the pulping units are discharging the pulping wastewater into the river. The discharging wastewater has an impact on the receiving water bodies and the impact can be evaluated by modelling studies. A model is defined as a theoretical construct with the use of some form of mathematical relationships which describes the

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various interrelationships among a set of variables or processes. There are a wide variety of models in environmental studies which will suit specific situations. For rivers and streams suitable models can be used as effective tools in management of water quality by policy makers, decisions makers, engineersand scientists.

Dissolved Oxygen an Important Water Quality Indicator

Dissolved Oxygen (DO) is one of the most significant components of natural water system and it indicates the index of river health. The effects of low DO concentration will lead in an unstable environment, fish death as well aesthetic disturbance such as disappointing colour, taste and odour. The level of Dissolved Oxygen (DO) is a reliable predictor of a body of surface water's pollution status. Depending on the amount of DO present, it is possible to classify polluted surface water into 4 groups:

Dissolved oxygen <5% of saturation (extremely severe pollution): Water with a faecal or foul egg smell is expected to be extremely viscous and dark grey or black in colour. The bottom seems to be covered in black muck by which gas bubbles may be rising. Gases such as hydrogen sulphide (H_2S), ammonia (NH_3), and carbon dioxide (CO_2) will predominate. In terms of biology, bacteria will dominate so there will be some invertebrates that can endure such severe pollution. In a normal situation, no fish will be present.

Dissolved oxygen 5%–10% of saturation (severe pollution): The water is prone to be murky in colour with a bad or rotten smell. Bottom mud may be grey on the top but black beneath when oxygen is lacking. Sewage fungus, a collection of organisms dominated by the bacteria *Sphaerotilus natans* that forms long, grey layers in the water, is what biologically defines this type of water. Normally, fish aren't present.

Dissolved oxygen 10%-70% of saturation (moderate pollution): The water is generally transparent or slightly murky, uncolored and odor less. If algae are present in the water, oxygen production will fluctuate throughout the day. Fish and invertebrates will be able to withstand some pollution in the water because of the abundance of plants and invertebrates in the water.

Dissolved oxygen >70% of saturation (no or slight pollution): In most cases, the water will be crystal-clear and odor-free. It will be usual for the water to be completely saturated with dissolved oxygen. The most pollution-sensitive invertebrates and fish species will be there.

In Coorg and Chikkamagalur most of the coffee pulping units are located in the coffee estates. Many of the coffee estates are located on the banks of rivers and streams. Coffee pulping activity is a seasonal activity and during such seasons the river flow will be low and the impact of the coffee pulping wastewater discharge into rivers will be more since wastewater containing high concentration of BOD, COD and nutrients with low pH. At present many of the coffee pulping units are not treating coffee pulping wastewater in a systematic way. This study is done to provide a technology for treating coffee pulping wastewater. Also, model studies have been done to study the impact of coffee pulping wastewater on receiving water bodies.

In Fig. 1 Schematic representations of the most critical modelling DO operations are provided. Oxygen in the aquatic environment is created by photosynthesis of algae and plants as well as absorbed by breathing of plants, animals as well as bacteria, BOD degradation cycle, sedimentary oxygen demand as well as oxidation. It is re- aerated through exchange with the atmosphere. These practices are considered for the modelling of DO in surface water bodies.

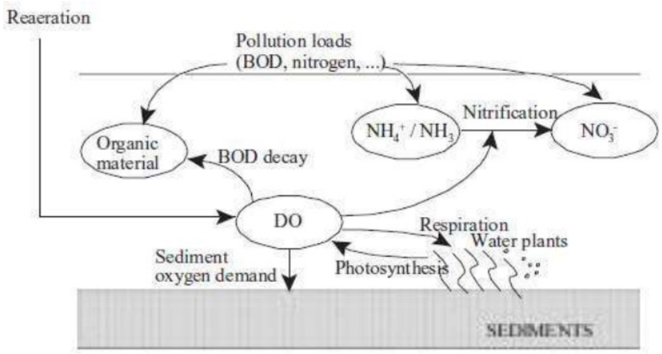

Fig. 1 Processes related to modeling of dissolved oxygen.

Pollutant Transport in Rivers

Most of coffee pulping units are located in the valleys of rivers and streams. Many of the pulping units does not provide complete treatment and sometimes partially treated or raw wastewater is discharged to nearby rivers and streams. Also, the coffee pulping will be done in the months of November and January during which the river flow will be low and the impact of coffee pulping wastewater will be more on receiving water bodies.

It is the relativity as well as the rate of physical transit that define the destiny of contaminants in aquatic environments.Transport of pollutants from air to water and from land to water has become increasingly important pathway for the occurrence of water pollution. The aquatic chemistry of the pollutants and the fate of the environment help in their transport and transformations.

The reactions that chemically undergo are a significant component of a chemical fate in the environment, but a similarly vital process has to do with the frequency of a chemical movement in the aquatic environment. Toxic chemicals appear in two forms in natural waters: dissolved and sorbed at low concentrations. Dissolved compounds are carried by water flow. They are completely sucked into the flow and are moving at the speed of the water. Likewise, chemicals that are sorbed to colloidal particles or fine suspended solids are effectively compacted in the current, but they may undergo additional transport process These compounds are dispersed in water, which is what the term "dispersion" alludes to. There are three possible directions for dispersion.

MATERIALS AND METHODS

Water Quality Monitoring and Analysis: Study Area-Madapura River Stretch

Each station's fieldwork included collecting river water samples (transect). A study looked at how the flow of water changed over time. It also looked at the temperature of the water and the pH, as well as the electrical conductivity, the DO, the TDS and TSS, and the orthophosphates as phosphorus, ammonium as nitrogen (NH4 N), nitrate as nitrogen, and the COD. Water samples collected, transported and tested following established protocols (APHA, 1998). Samples were obtained in a 1000 ml polythene bottles. An on-site lab ran a variety of experiments to measure things like river flow and velocity as well as other environmental variables like temperature and the pH, EC, and DO levels. Temperature, pH, DO and EC were monitored using portable sensors. Water flow velocity is determined using floats. The departmental laboratory tested the remaining variables. Filtration and a temperature-controlled oven were used to measure the total amount of suspended particles. It took five days of incubation at 20°C to ascertain the level of BOD. COD concentration was evaluated by oxidation with potassium dichromate in concentrated sulphuric acid medium (open reflux, titrimetric method) (open reflux, titrimetric method). The nesslerization method was used to measure the ammonium nitrogen concentration. Nitrate and nitrite nitrogen concentrations were evaluated using UV screening technique. Orthophosphate concentration was tested using phosphomolybdate technique.

Models used for Predictions

Computer programmes have been developed for the data analysis as well as for river water quality predictions which were used for the study. The programmes such as MIXANDAT and MULTMIX have been made use of in the prediction and evaluation of dissolved oxygen in shallow rivers.

MIXANDAT: The river hydraulic data acquired during the field study is analysed using the MIXANDAT computer tool developed by (Gowda, 1980). In this programme, the cross sectional sampling data for conservative as well as non-conservative water quality parameters, as well as cross sectional depth and velocity profiles, are used as input (optional). The application is set up to receive data at upto ten transects and 60 values of lateral distances, depths, velocities and concentrations at each transect. Conductivity variance distributions and mass flux cross-sections can be used to analyse dispersion parameters such as shape velocity factor (considered a tracer). The widths, depths, velocities, concentration and mass flux figures were printed out for each transect for each of the components. The average depth, velocity, shape velocity factor, as well as diffusion factor of each transect are all provided in the report.

MULTIMIX: The computer program with acronym MULTMIX for each run gives the tables of lateral and longitudinal concentration distributions of Carbonaeceous BOD (CBOD), Nitrogeneous BOD (NBOD) and DO deficit in river channel receiving effluents from bank outfall at different locations downstream. Also, the lateral and longitudinal distributions due to combined effects of different outfalls are predicted (Manoj Kumar, 1991).

In order to run the MULTMIX program, the input data required are:

• Number of effluent outfalls.

• Number of transects including effluent outfall locations.

• Distance downstream to various transects from first outfall in meters. (Transect 1 is not considered for modeling since this transect is considered as background water quality station).

• Average width, depth and velocity of river channel for each transect.

• Observed river temperature at the time of study.

• The river background parameters such as stream flow rate, CBOD, NBOD and DO concentration.

• Effluent discharge details and effluent concentrations for the outfalls.

Besides the above, the value of β which is a non-dimensional dispersion value predicted through the MIXANDAT programme is also utilized to run the MULTMIX programme. The output of the model MULTMIX includes detailed tables of the lateral distributions of CBOD, NBOD and DO at each transect for each source and combined concentration distribution of these parameters for the entire selected reach of the river. MULTMIX programme output gives the DO deficit for each parameter such as CBOD, NBOD and DO deficit in the effluent, as well as the total deficit of DO and the remaining DO in the river, for each transect. From these result, the critical DO concentrations and their distances can be calculated. These critical distances and critical DO are helpful in selecting the type of treatment to be given to the effluent being discharged into the river.

Field Survey Procedure

Eight transects will be used to gather data on outfall discharge plus background water quality attributes, as well as the transverse dispersion of a variety of parameter-relevant variables. The parameters of field survey mainly depend on the location factors. For modeling purpose a river stretch near Madapur town located in Somwarpet Taluk of Kodagu district which is situated near Mysore-Madikeri highway was selected. This stretch was selected based on accessibility and coffee plantations are located on either banks of the river. For the selected river stretch, the effluents outfall location and transects monitoring were done. In the river stretch near Madapura town for a distance of 4.06 km at ten transects river water hydraulic and quality studies were done. Transects were fixed based on the effluent outfall locations and accessibility to the river. The distance of transects and its location are shown in Table 1.

There are a few access sites in the mixing zone where early measurements of a conservative parameter (here conductivity) can be made, thus transects can be laid out to determine the approximate longitudinal limit of this zone. The cross-sectional depth was determined at a minimum of 15 places at known lateral distances determined from a reference bank (typically the outfall bank) (usually the outfall bank). Velocity measurements were also recorded at various sites in each transects.

The water samples were taken at the upstream boundary and at the effluent outfall. They were also taken at each point where cross-sectional depths and velocities were measured. It was decided to collect samples in two ways: Either by following a single plug of water from an outfall to a series of downstream transects or by conducting a 24-hour intensive survey in which samples are collected every 3-4 hours to account for possible effects of fluctuations in effluent water quality and discharge on in-stream concentrations. The items used for monitoring of the river (river hydraulic and quality) include: Raft (boat), measurement rope, measuring tape, cans for sample collection, on-line monitoring metres such as DO metre, conductivity metre, pH metre and TDS metre. It was necessary to preserve the sample preservator before testing it. Temperature, DO, pH, and conductivity were all measured on-site, and samples were collected and sent to the lab for testing for potential non-conservation pollutants.

Tab.1. Location details of various transects for river water quality modeling.

Transect number	Distance from reference point, m	Location details
	1*	**Biligere-Nandimotte culvert**
1	10	Downstream of Biligere-Nandimott Culvert
2	490	-----
3	1000	-----
	1200*	-----
4	1260	Near old walkway bridge, Billigeri
5	1385	
6	1600	-----
	1620*	-----
7	1760	-----
8	2270	-----
9	2920	-----
	3000*	Front of cumbour estate
10	3260	Front of cumbour estate on road
11	3660	
12	4060	Below bridge (Suntikoppa-Madikeri road)

Note: * Outfall distance from Biligere-Nandimotte culvert.

Analysis of Data

This is the continuation stage after the field survey. The parameters needed for the modelling process are derived from the field survey data. The field survey data is fed into a computer software named MIXANDAT (Gowda, 1980). This programme performs the following calculations.

• Average depth as well as velocity at each transect.

• Shape velocity factor for each transect, based on simulations of velocity distributions at cross-sections where speeds are not measured.

• Mass flow values of conservative as well as non-conservative materials at each transect.

The analytical data was collected from the previous study which is used to run the various prediction tools. Sensitivity analysis was performed to determine the permissible BOD that is to be present in the coffee pulping wastewater to maintain optimum DO in the selected stretch of river Cauvery. A treatability study is performed to obtain the permissible BOD in the coffee pulping wastewater using EC method.

Coffee Pulping Wastewater Impact Prediction on Cauvery River Water

In this section river water quality prediction using mixing zone model “MULTMIX” has been presented. In the present study computer models were used to predict Cauvery river water quality at selected stretch near Madapura town. This stretch was selected since coffee pulping units are located on either side of the river. Monitoring data for a stretch of 4.06 km of the river at 9 different transects were used in MIXANDAT programme. The computer programme MIXANDAT was used to calculate the cross sectional distribution of flow, average values of depth and velocity, as well as mass flux and variance at each transect using the values of depth and conductivity (APHA,1980). River hydraulic data and conductivity data are used for obtaining non- dimensional dispersion co-efficient presents the location details of 9 transects used for modelling studies (Table 2).

River Data Analysis Using Mixandat Programme

The inputs to MIXANDAT programme also include cross-section data collected for conservative water quality parameter, cross sectional depth as well as velocity profiles. The programme simulates local velocities at transects when they are not measured while the output contains mass flux, cross sectional distributions of flow and concentrations, variance of conductivity distributions required to set up dispersion characteristics and shape velocity parameters. With the output, you will be able to see for each transect the average depth, the average velocity, the shape velocity, and the diffusion factor. The distances to each transect and values of top width, mean depth and mean velocity at each transect derived by MIXANDAT model are reported in the Table 3. The average velocity varied between 0.01 to 0.21 m/s, the width of the river at various transects varied between 21 to 42.5 m and the average depth at various transects varied between 0.35 m to 3.12 m. A flow rate of 1.27 m^3/s was measured in the river.

Tab. 2. Location details of various transect.

Transect number	Distance from Reference (m) Point, m	Location details
Reference transect	0	Biligere-Nandimotte culvert
1	10	Coffee pulping wastewater outfall
2	1010	------
3	1200	Near old walkway bridge, Billigeri
4	1385	Coffee pulping wastewater outfall
5	1620	------
6	1760	------
7	2920	Front of Cumbour coffee estate
8	3260	Front of Cumbour coffee estate on road
9	4060	Below bridge (Suntikoppa-Madkeri road)

Tab. 3. Hydraulic parameters analyzed by MIXANDAT program

Transect	Distance from reference transect (km)	Average width, m	Average depth, m	Average velocity, m/s
1	10	42.5	3.12	0.010
2	1010	22.5	2.28	0.025
3	1200	21.0	0.90	0.071
4	1385	24.3	0.82	0.067
5	1620	25.9	0.78	0.066
6	1760	27.5	0.77	0.067
7	2920	25.7	0.65	0.085
8	3260	25.0	0.57	0.106
9	4060	22.0	0.35	0.21

The output of MIXANDAT programme was used in MULTMIX model in addition to this the two coffee pulping wastewater quantity and quality data was also used in the model. The combined effect of two outfalls on DO content of river is presented in this section.

Do Prediction Using MULTMIX Model

MULTMIX programme output gives the DO deficit for each parameter such as CBOD, NBOD and DO deficit in the effluent, as well as the total deficit of DO and the remaining DO in the river, for each transect. From the results, the critical DO concentrations and their distances can be calculated. These critical distances and critical DO are helpful in selecting the type of treatment to be given to the coffee pulping wastewater being discharged into the river.

The MULTMIX model was used to predict DO distribution in river water with different discharge options by two outfall sources, the first outfall and located at 10 m and second outfall is located at 1385 m from the reference station. The discharge at first outfall takes place at the rate of 0.035 m^3/s while the 3 discharge at second outfall is 0.04 m/s. The scenarios with discharge options considering for different treatment levels are tabulated in Table 4. The DO distribution prediction by MULTMIX model with different discharge options are shown in Figs. 2A-2I respectively.

Tab. 4. Scenarios considered for DO prediction with different treatment levels to coffee pulping wastewater.

Scenario no	1st outfall (CBOD/NBOD)	2nd outfall (CBOD/NBOD)
1	Raw (5400/5)	Raw (4500/40)
2	Raw (5400/5)	EC treated (450/16)
3	Raw (5400/5)	EC+ASBR treated 162/9
4	Raw (5400/5)	No discharge
5	EC (533/18)	Raw (4500/40)
6	EC (533/18)	EC treated (450/16)
7	EC (533/18)	EC+ASBR treated 162/9
8	EC+ASBR treated 200/9	Raw (4500/40)
9	EC+ASBR treated 200/9	EC+ASBR treated 162/9
1760	1760	1760

RESULTS

From coffee pulping wastewater discharge impact studies for a stretch of river near Madapur town, it was observed that only when the wastewater is given complete treatment i.e. (Electrocoagulation +Sequencing Batch Reactor) (EC+SBR), the minimum required DO level of 4 mg/l can be complied. For several scenarios (Different treatment options) Model predictions were done using MULTMIX model. The predictions done for discharge options in scenario 6 (when both outfall are EC treated), scenario 7 (when first outfall is EC treated and second is EC +SBR treated) and scenario 8 (when only first outfall takes place and no discharge from second outfall), resulted in a reasonably a good DO concentration in the river water. For the discharge options in scenario 11 (when both the sources are completely treated i.e., EC+SBR), is the best and ideal option to maintain the permissible DO level through the river stretch. Discharge of raw coffee wastewater with different flow rates i.e., at 0.005, 0.01, 0.02, 0.03 and 0.04 m^3/s were simulated using MULTMIX model. It is observed that a minimum permissible concentration of 4 mg/l for DO can be achieved by raw effluent discharge, only if wastewater is discharged at rate of 0.005 m^3/s, except for a stretch between 1500 to 2500 m where a DO concentration of 3.5 mg/l can be maintained. Discharge of EC treated coffee pulping wastewater with different flow rate i.e., at 0.005, 0.01, 0.02, 0.03 and 0.04 m^3/s was simulated. It is observed that a minimum permissible concentration of 4 mg/l for DO can be achieved only if discharged at 0.01 m^3/s and DO concentration of 5 mg/l can be achieved if discharged at 0.005 m^3/s.

Fig. 2A illustrates the DO prediction for scenario 1, in which the untreated coffee pulping wastewater is discharged at both the outfalls. The first outfall having CBOD value of 5400 mg/L and the second outfall having CBOD value of 4500 mg/L. Due to high CBOD values the DO level has decreased to zero upto 10% Limited Use Zone (LUZ) (outfall bank) throughout the river stretch. As the river flows downstream from the discharge location, the process of bacterial oxidation of organic matter utilizes more oxygen than re-aeration can compensate for. Therefore, the concentration of DO in the river decreases up to 0 mg/L. The DO level at 20%, 30% and 40% LUZ decreases below 4 mg/L at different rate. It can be seen that the rates of de-oxygenation increase (decrease in DO concentration) suddenly after 1385 m indicating the impact of second outfall. The rate of de-oxygenation reflects the BOD exertion rate in the stream. It can be seen that the rate of de-oxygenation becomes equilibrium with the rate of re-aeration at 3200 m. From this point onwards, re-aeration becomes the dominant force as it replaces the river's oxygen more quickly than the oxidation of organic matter has reduces it. The DO at all LUZs starts increasing until it is back to its ambient value of 100% of air saturation. The model prediction shows that the DO level is above 4 mg/L from 50% LUZ onwards indicating a positive DO gradient from discharge bank towards opposite bank and can serve as ZOP for fishes and other desirable aquatic life.

Fig. 2B illustrates the DO prediction for scenario 2, in which untreated coffee pulping wastewater is discharged at first outfall with CBOD value of 5400 mg/L and with EC treated coffee pulping wastewater at second outfall with CBOD value 450 mg/L. For this scenario the DO level is zero upto 10% LUZ from 1500 m to 3000 m of the river stretch due to the discharge of wastewater from both the outfalls. Compared to previous scenario the DO level starts improving from 3200 m justifying that the efficacy of EC treated effluent having relatively lower impact compared to untreated effluent discharged to river. For this scenario the MULTIMIX model prediction shows that 50% of lateral distance from the outfall bank will have DO concentration of less than 4 mg/L.

Fig. 2C shows the DO prediction for scenario 3, where in raw coffee pulping wastewater is discharged at first outfall with CBOD value of 5400 mg/L and with EC+ASBR coupled treated discharge at second outfall with CBOD value of 162 mg/L. In this scenario the DO concentration starts increasing above 0 mg/l from 2500 m justifying that the EC+ASBR treated effluent has relatively lower impact compared to only EC treated effluent.

Fig. 2D illustrates the DO prediction for scenario 4, in which raw coffee pulping wastewater is discharged at first outfall with CBOD value of 5400 mg/L and with no discharge taking place at second outfall. For this scenario the DO concentration starts increasing above 0 mg/l from 2000 m at 0% and 10% LUZ. Also, from outfall bank after 40% LUZ, the DO concentration is more than 4 mg/L till opposite bank.

Fig. 2E illustrates the DO prediction for scenario 5, in which effluent is discharged with EC treated coffee pulping wastewater with CBOD value of 533 mg/L at first outfall and raw coffee pulping wastewater discharged at second outfall with CBOD value of 4500 mg/l. The DO predictions showed that except at outfall bank they DO values were more than 4 mg/L up to second outfall (1400 m downstream). The DO concentration has decreased to a maximum of 1.0 mg/L at 3000 m and starts recovering immediately towards saturation. The decrease in DO after 1400 m is the effect of second outfall wherein raw coffee pulping wastewater is getting discharged. This scenario is better compared to scenario 2 in which the first outfall discharged raw coffee pulping wastewater and second outfall discharged EC treated wastewater and the DO level remains below 1 mg/L upto 3200 m implying relatively higher impact.

Fig. 2F illustrates the DO prediction for scenario 6, in which both the 1st and 2nd outfall are EC treated having CBOD values of 533 mg/L and 450 mg/L respectively. The DO level has decreased to a maximum of 3.2 mg/l and prevails for a distance of 800 m from 1800 to 3000 m because the rate of deoxygenation is in equilibrium with rate of reaeration. The DO level starts increasing from 3000 m when the rate of reaeration exceeds the rate of deoxygenation.

Fig. 2G shows the DO prediction for scenario 7, in which the first outfall is EC treated with CBOD value of 533 mg/L and second outfall is EC+ASBR coupled treated with CBOD value of 162 mg/L.

The MULTMIX prediction shows that DO decreases to maximum of 3.2 mg/L and starts recovering immediately to 4 mg/L at 3000 m onwards justifying the effectiveness of addition SBR treatment at second outfall compared to that in scenario 6. The prediction also shows that after 20% LUZ laterally from outfall bank the DO is more than 4 mg/L.

Fig. 2H presents the DO prediction of MULTMIX model for scenario 8, in which the effluent discharged at first outfall is EC+ ASBR coupled treated with CBOD value of 345 mg/L and the effluent discharged at second outfall is raw coffee pulping wastewater with CBOD value of 1500 mg/L. The DO level predicted decreases near to 2 mg/L at 3000 m and starts recovering immediately. This scenario is much better compared to scenario 3 in which the first outfall has untreated effluent discharge and second outfall has EC+ASBR coupled treated wastewater and the DO level is below 2 mg/L up to 30% LUZ till 4060m. For this option, the two outfalls characteristic input was

EC+ASBR coupled wastewater treated values. For worst case scenario, the EC+ASBR treated CBOD values considered is 200 mg/L for first outfall and 162 mg/L for second outfall. During laboratory scale studies done for coffee pulping wastewater the EC+ASBR coupled treatment system achieved BOD concentration of less than 36 mg/L.

Fig. 2I illustrates DO prediction for scenario 9, in which the effluent at both the outfall is discharged with EC+ ASBR treatment with CBOD values of 345 mg/L and 126 mg/L. This scenario is the most ideal scenario in which the minimum DO level of 4 mg/L is compiled after the first outfall from 800 m onwards. The DO level drops from 5 mg/L to 4 mg/L due to impact of second outfall at 1385 m and immediately starts improving towards saturation justifying the efficacy of EC+ASBR coupled treatment compared to only EC treatment option (Radwan, et al., 2003).

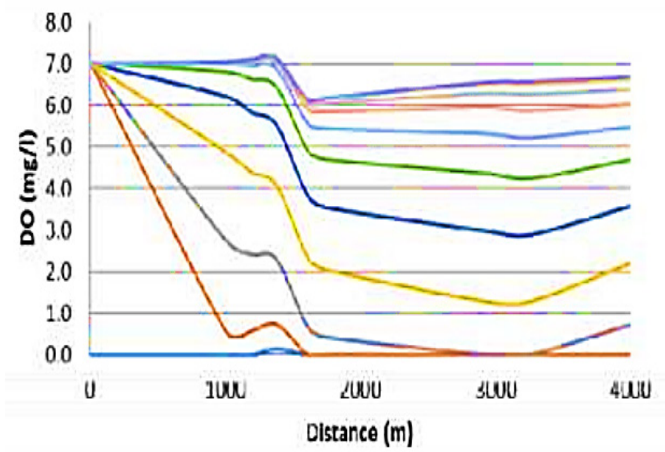

Fig. 2A DO prediction for scenario 1, raw coffee pulping wastewater discharged at both outfalls. **Note:** (——) 0%LUZ; (——)10%LUZ; (——)20%LUZ; (——)30%LUZ; (——)40%LUZ;(——)50%LUZ;(——)60%LUZ;(——) 70%LUZ; (——)80%LUZ.

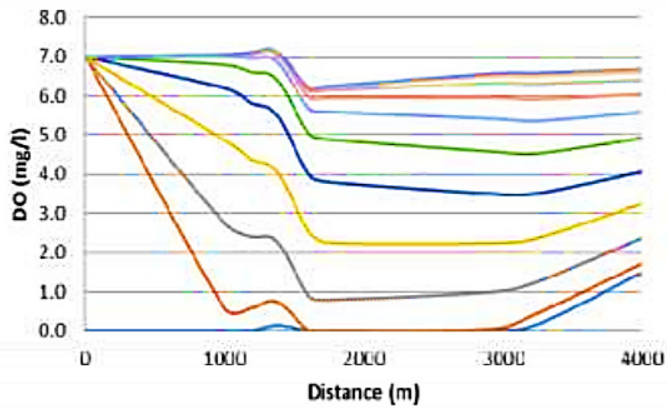

Fig. 2B DO prediction for scenario 2, raw coffee pulping wastewater discharged at first outfall and EC treated wastewater discharged at second outfall. **Note:** (——) 0%LUZ; (——)10%LUZ; (——)20%LUZ; (——)30%LUZ; (——)40%LUZ;(——)50%LUZ;(——)60%LUZ;(——) 70%LUZ; (——)80%LUZ.

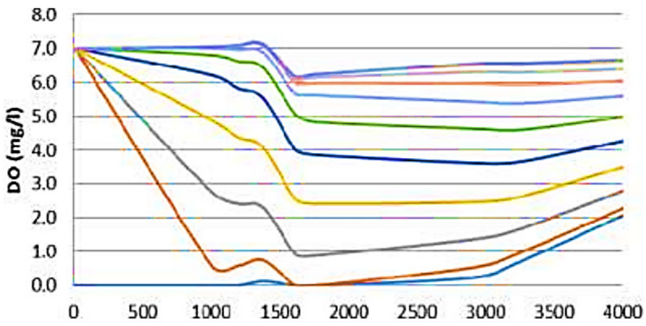

Fig. 2C DO prediction for scenario 3, raw coffee pulping wastewater discharged at first outfall and EC+ ASBR coupled treated discharged at second outfall. **Note:** (——) 0%LUZ; (——)10%LUZ; (——)20%LUZ; (——)30%LUZ; (——)40%LUZ;(——)50%LUZ;(——)60%LUZ;(——) 70%LUZ; (——)80%LUZ.

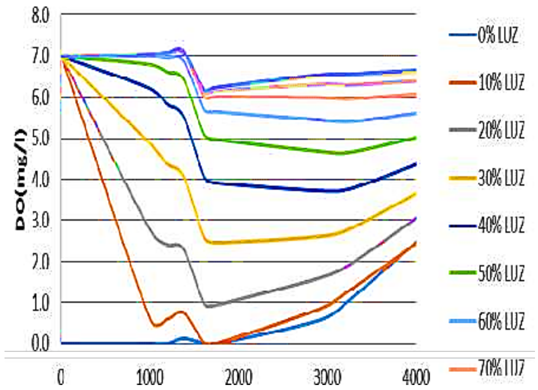

Fig. 2D DO prediction for scenario 4, raw coffee pulping wastewater discharged at first outfall and no discharge at second outfall. **Note:** (——) 0%LUZ; (——) 10%LUZ; (——)20%LUZ; (——)30%LUZ;(——) 40%LUZ; (——)50%LUZ; (——)60%LUZ; (——) 70%LUZ; (——)80%LUZ.

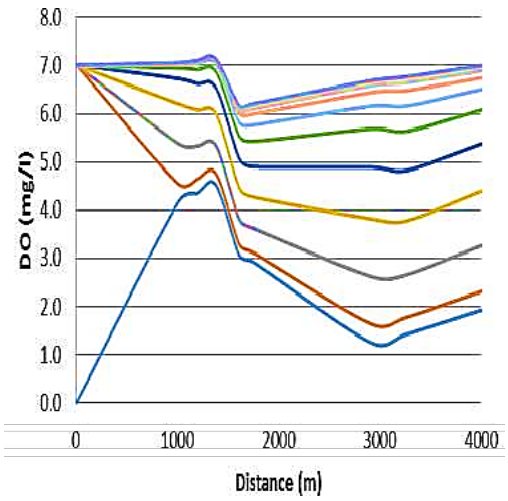

Fig. 2E DO prediction for scenario 5, EC treated coffee pulping wastewater discharged at first outfall and raw coffee pulping wastewater discharged at second outfall. **Note:** (——) 0%LUZ; (——) 10%LUZ; (——)20%LUZ; (——)30%LUZ;(——) 40%LUZ; (——)50%LUZ; (——)60%LUZ; (——) 70%LUZ; (——)80%LUZ.

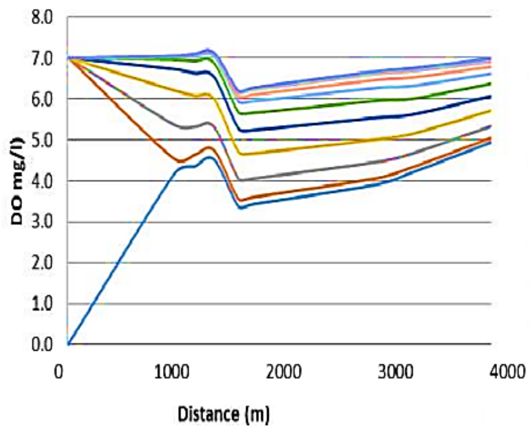

Fig. 2F DO prediction for scenario 6, EC treated coffee pulping wastewater discharged at both outfalls. **Note:** ( ) 0%LUZ; ( )10%LUZ; ( )20%LUZ; ( )30%LUZ; ( )40%LUZ;( )50%LUZ;( )60%LUZ;( ) 70%LUZ; ( )80%LUZ.

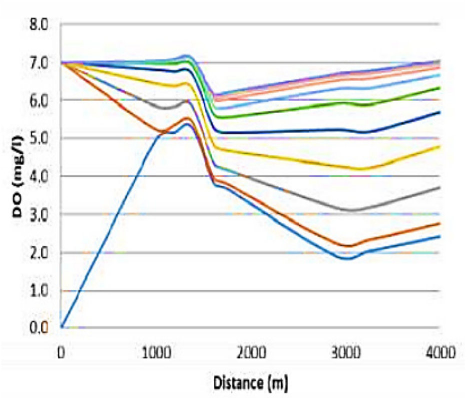

Fig. 2G DO predictions for scenario 7, EC treated coffee pulping wastewater discharged at first outfall and EC+ASBR coupled treated effluent discharged at second outfall. **Note:** ( ) 0%LUZ;( )10%LUZ;( )20%LUZ;( )30%LUZ; ( )40%LUZ;( )50%LUZ;( )60%LUZ;( ) 70%LUZ; ( )80%LUZ.

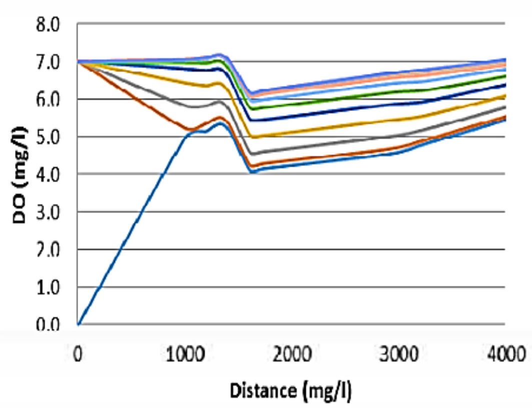

Fig. 2H DO prediction in scenario 8, EC+ASBR treated coffee pulping wastewater discharged at first outfall and raw coffee pulping wastewater discharged at second outfall. **Note:** ( ) 0%LUZ;( )10%LUZ;( )20%LUZ;( )30%LUZ; ( )40%LUZ;( )50%LUZ;( )60%LUZ;( ) 70%LUZ; ( )80%LUZ.

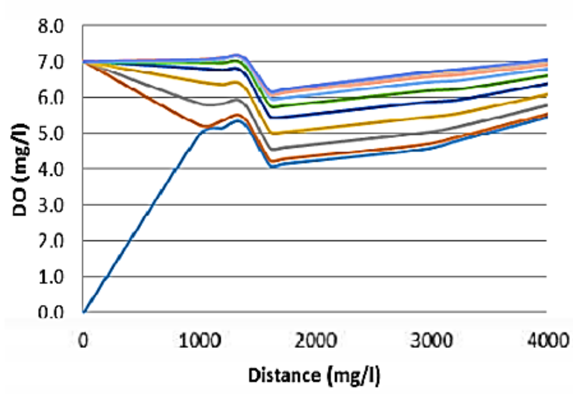

Fig. 2I DO prediction for scenario 9, EC+ ASBR treated coffee pulping wastewater discharged at both outfalls. **Note:** ( ) 0%LUZ;( )10%LUZ;( )20%LUZ;( )30%LUZ; ( )40%LUZ;( )50%LUZ;( )60%LUZ;( ) 70%LUZ; ( )80%LUZ.

CONCLUSIONS

From the present study the following conclusion has been drawn:

1. Coffee pulping wastewater used for SBR studies was characterized by low pH 3.92, high COD concentration in the range 8320 mg/L to 10400 mg/L, ammonia nitrogen concentration was in between 50 to 54 mg/L, nitrate nitrogen concentration ranged from 32 mg/L to 52 mg/L and phosphorus concentration was in the range 60 mg/L to 94 mg/L respectively.

2. MIXANDAT programme was used to analyze the data collected at various transects in the river stretch during the field survey. The output of MIXANDAT programme was utilized to run mixing zone model.

3. From the coffee pulping wastewater discharge impact studies for a stretch of river near Madapur town, it can be observed that only when the wastewater is given complete treatment i.e. (EC+ASBR), the minimum DO level of 4 mg/L can be complied.

4. The discharge option in scenario 6 i.e., when both outfalls are EC treated, scenario 7 i.e., when first outfall is EC treated and second outfall is EC+ASBR treated and scenario 8 i.e., when only first outfall takes place and no discharge from second outfall, results in a reasonably good DO concentration in river water.

5. The discharge option in scenario 9 i.e., when both the sources are completely treated (EC+ASBR) treated is the best and an ideal option to maintain the permissible DO level thought the river stretch.

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