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DESIGN AND STUDY OF PACKED BED REACTOR FOR DECOLOURIZATION OF MOLASSES BASED DISTILLERY SPENT WASH

Shubha Anand[1]* and Ishwar Chandra[2]

ABSTRACT

Alluvial soil samples from the area of Molasses based distillery in Uttar Pradesh (India) were used for the treatment of distillery effluent. Color removal of distillery spent wash was achieved using packed bed reactor studies in batch mode. Biophysical properties (adsorption and microbial population) of soil were utilized for the adsorption and simultaneous degradation of recalcitrant compounds i.e. melanoidins present in the distillery effluent. The microbes naturally present in soil sample nearby the distillery plants owing to prolonged exposure to spent wash and hence evolved to degrade the melanoidins were employed for the color removal of effluent during movement across the reactor bed. The reactor bed with soil and soil-bagasse-sand combination was studied for eight months, revealing a maximum of 90 and 95 % color removal efficiency, respectively. Reactor bed shrinkage of 2 – 5 % and residence time of 12 to 48 hrs was reported for both the reactor beds, respectively. Thus it was concluded that owing to its natural microbiota and physical adsorption properties, soil can effectively and economically be used for the treatment of distillery spent wash.

Keywords: *Spent Wash, Packed Bed Reactor, Bioadsorbent*

INTRODUCTION

The various by-products of sugar industry includes molasses, bagasse and fiber cake. Molasses being a good source of sugar (48 – 50 %) is used in various industries including distilleries, cattle feed and bio-fertilizers. Molasses based distilleries in India utilize this by-product for the production of alcohol. For every liter of alcohol produced, 8 – 15 lit of wastewater known as spent wash is generated *(Pazouki et al., 2008)*. The spent wash contains a highly recalcitrant compound, melanoidins that are complex and resistant to microbial degradation. Along with this, spent wash also has high BOD (35, 000 – 50,000 ppm) and COD (85,000-130,000 ppm) values that poses serious environmental threats *(Sankaran et al., 2011).*

Untreated spent wash is highly toxic in nature and produce harmful effects such as:

- Decrease in sunlight penetration and increase in temperature of water.
- Decrease in soil alkalinity and Manganese availability.
- Inhibit seed germination (*Agarwal et al., 1994; Kumar et al., 1997; Jun et al., 2009*).
- Decreased photosynthetic activity and dissolved oxygen concentration

Treatment of spent wash using pseudomonas and Aeromonas bacterial species have been studied with colour removal efficiency of 60% *(Ghosh et al., 2002)*. Also melanoidins degradation with modified soil containing lignocellulosic derivatives with immobilized cells have been analysed with higher color removal efficiency (*Singh et. al, 2021*). Studies have also suggested the use of low cost adsorption material eg. peat, benomite, steel plant slag, fly ash, china clay and agricultural waste (maize cob, wood shavings, corn cob shred and wood chips, seeds etc) have proved to be highly useful for decolourization.

The current study proposes a method that involves the use of un- modified natural soil for the treatment of anaerobically digested molasses based distillery spent wash. Melanoidins are removed by adsorption on soil particles as well as through biological degradation by naturally occurring microbes in soil as they move through the length of the reactor bed. Thereby also enriching the soil with essential minerals present in distillery spent wash and thus improving the quality of the soil.

MATERIALS AND METHODS

1. Distillery Effluent The bio-methanated spent wash was collected from Modi Distillery in Modi Nagar, district Gaziabad, Uttar Pradesh, India. The sample was taken by random sampling method from oxidation pond where it has been left for disposal after anaerobic treatment.

2 Soil Sample The soil sample was collected from the site of discharge of the effluents to the environment and same used as decolourizing agent to study the optimization of pollutant biodegradation.

3. Packed Bed Reactor Studies: The principle behind a Packed Bed Reactor is that cells are immobilized within a suitable stationery matrix that forms the bed. The bed provides a large surface for cell entrapment. Distillery effluents allowed to perfuse through the bed under natural gravity, which moves across the bed by capillary seepage. The distillery effluent makes contact with bed. This allows the reactor to run in continuous mode.

1. *Lecturer, Dayalbagh Educational Institute, Dayalbagh, Agra-282005, U.P, India.*
**Corresponding author: shubhaanand@dei.ac.in*
2. *Assistant Professor, Sir M Visvesvaraya Institute of Technology, Krishnadeveraya Nagar, Hunasamaranahalli, Bangalore-562157,India*

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The packed bed reactor used for the current project work is made up of laboratory grade plastic. The Reactor is provided with one inlet hole, and three outlet holes to maintain the flow of the distillery effluent across the bed. Two batches were run with the variable reactor bed composition and the distillery effluent concentration.

Batch 1: In the first batch the reactor bed composition was kept constant to be natural soil and the reactor was run for all the effluent concentrations that is from 10 % to 100 %.

Batch 2: Corresponding to the results of batch 1, in batch 2 the effluent concentration was kept constant at 40 % as maximum color removal was achieved with this concentration and different reactor bed composition with sand:soil:baggase (*Shukla et al., 2018*) were used.

4. Recording the Reactor Parameters: During and after the run, the reactor parameters like bed shrinkage, voidage, effluent flow rate and melanoidins concentration at each outlet were recorded.

The samples thus collected at the reactor outlets are then analyzed by recording the OD at 475nm (absorption maxima of melanoidins) in the UV Spectrophotometer. The OD reading of the decolorized sample is then plotted on the standard graph of melanoidins to record the melanoidins concentration in the treated biomethanated distillery spent wash.

Reading of untreated effluent was also noted at 475nm and thus compared to calculate the melanoidin concentration reduced in the treated effluent using a standard graph.

Numerous drought indices have been used to detect and monitor droughts for many years. The standardized precipitation index (SPI) (McKee et al., 1993), Palmer drought severity index (PDSI) (Palmer, 1965), effective

RESULTS AND DISCUSSION

Packed bed reactor studies for the color removal of biomethanated distillery spent wash were performed in two batches with reactor parameters as mentioned in Table 1 and 2 respectively.

In batch 1 where the reactor bed consists of only soil and different dilutions of spent wash were run, the maximum color removal of 87.6% (Fig. 1) was achieved with 40 % of effluent dilution with corresponding melanoidins concentration of lowest recorded as 0.158 mg/ml (Fig. 2) . The process parameters including Bed Shrinkage, Residence time and output flow rate were recorded (Table 3). Maximum bed shrinkage of 10.10% was observed in reactor 2 with 41 hours of residence time coinciding with Reactor 7. The comparative colour of the spent wash before and after treatment is depicted in Fig 3.

Table 1: Reactor Parameters of Batch 1 Studies

S.No.	Reactor Bed Composition	Reactor Bed Height (cm)	pH of distillery effluent	InputFlow Rate (mlpermin)	Output Flow Rate (mlper)	Effluent Dilution (%)
Reactor1	Soil	21.7	7.5	0.01	0.01	10
Reactor2	Soil	21.7	7.5	0.01	0.01	20
Reactor3	Soil	21.7	7.5	0.01	0.01	30
Reactor4	Soil	21.7	7.5	0.01	0.01	40
Reactor5	Soil	21	7.5	0.01	0.01	50
Reactor6	Soil	22	7.5	0.01	0.01	60
Reactor7	Soil	22	7.5	0.01	0.01	70
Reactor8	Soil	22	7.5	0.01	0.01	80
Reactor9	Soil	22	7.5	0.01	0.01	90
Reactor10	Soil	22	7.5	0.01	0.01	100

Table 2: Reactor Parameters of Batch 2 Studies

S.No.	Reactor Bed Composition (Sand:Soil:Baggase)	ReactorBed Height (cm)	pH of Effluent	Input Flow Rate (mlpermin)	Output Flow Rate (mlpermin)	Effluent Dilution (%)
Reactor 1	60:60:60	18.5	8.14	0.3	0.2	40
Reactor 2	60:60:100	20	8.14	0.3	0.1	40
Reactor 3	60:100:60	19.5	8.14	0.3	0.1	40
Reactor 4	60:100:100	20.5	8.14	0.3	0.4	40
Reactor 5	100:60:60	18.5	8.14	0.3	0.1	40
Reactor 6	100:60:100	20	8.14	0.3	0.3	40
Reactor 7	100:100:60	21.5	8.14	0.3	0.2	40
Reactor 8	100:100:100	23.5	8.14	0.3	0.01	40

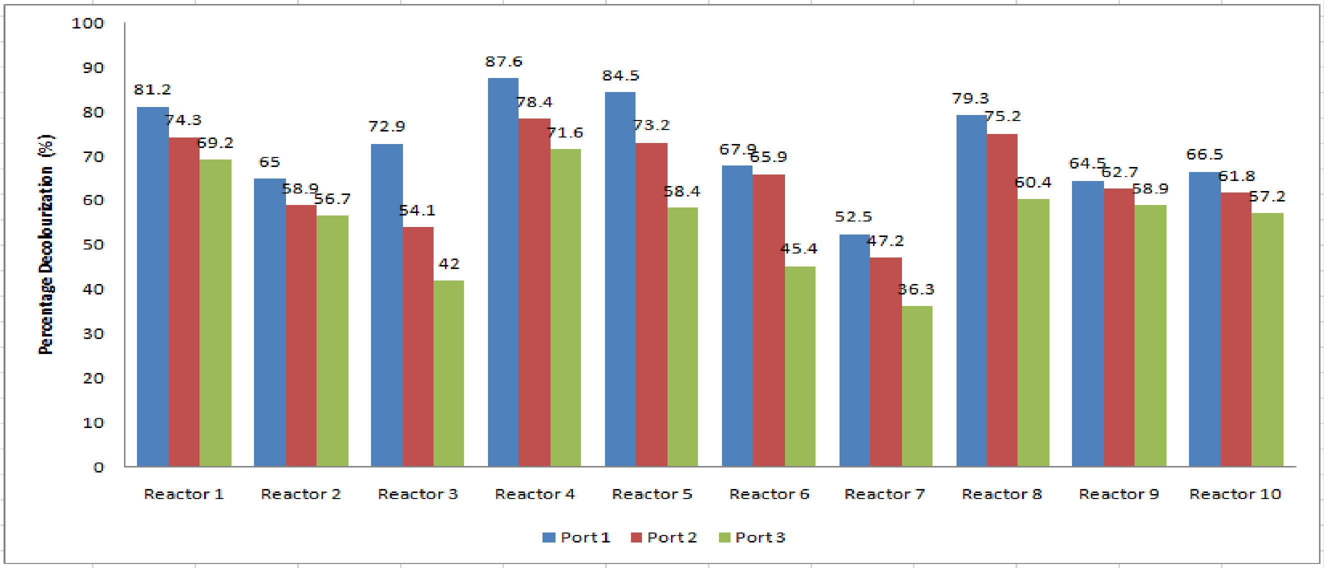

Fig. 1: Percentage Decoloration in Batch 1

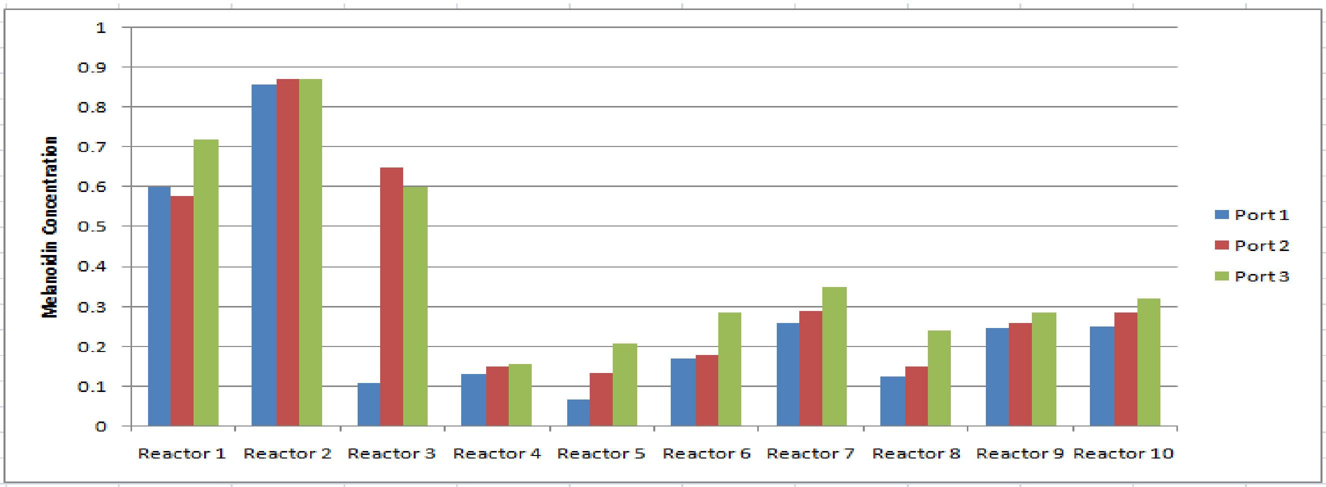

Fig. 2: Melanoidin Concentrations in Batch 1

Table 3: Process Parameters of Batch 1

Batch 1	Output Flow Rate (ml\sec)	Bed Height After Treatment	Bed Shrinkage (%)	Residence Time (hrs)	Decolorization(%)		
					Port 1	Port 2	Port 3
Reactor 1	0.01	20	7.8	40	84.3	74.3	69.2
Reactor 2	0.01	19.5	10.1	41	65	58.9	56.7
Reactor 3	0.01	20	7.8	40	72.9	54.1	42
Reactor 4	0.01	21	3.22	39	71.46	78.45	71.65
Reactor 5	0.01	21	3.22	40	84.5	73.2	58.4
Reactor 6	0.01	19	9.52	38	67.9	65.9	45.4
Reactor 7	0.01	21	4.5	41	52.5	47.2	36.3
Reactor 8	0.01	21.5	2.27	42	79.3	75.2	60.4
Reactor 9	0.01	21.7	1.36	40	64.5	62.7	58.9
Reactor 10	0.01	21.7	4.5	40	66.5	61.8	57.2

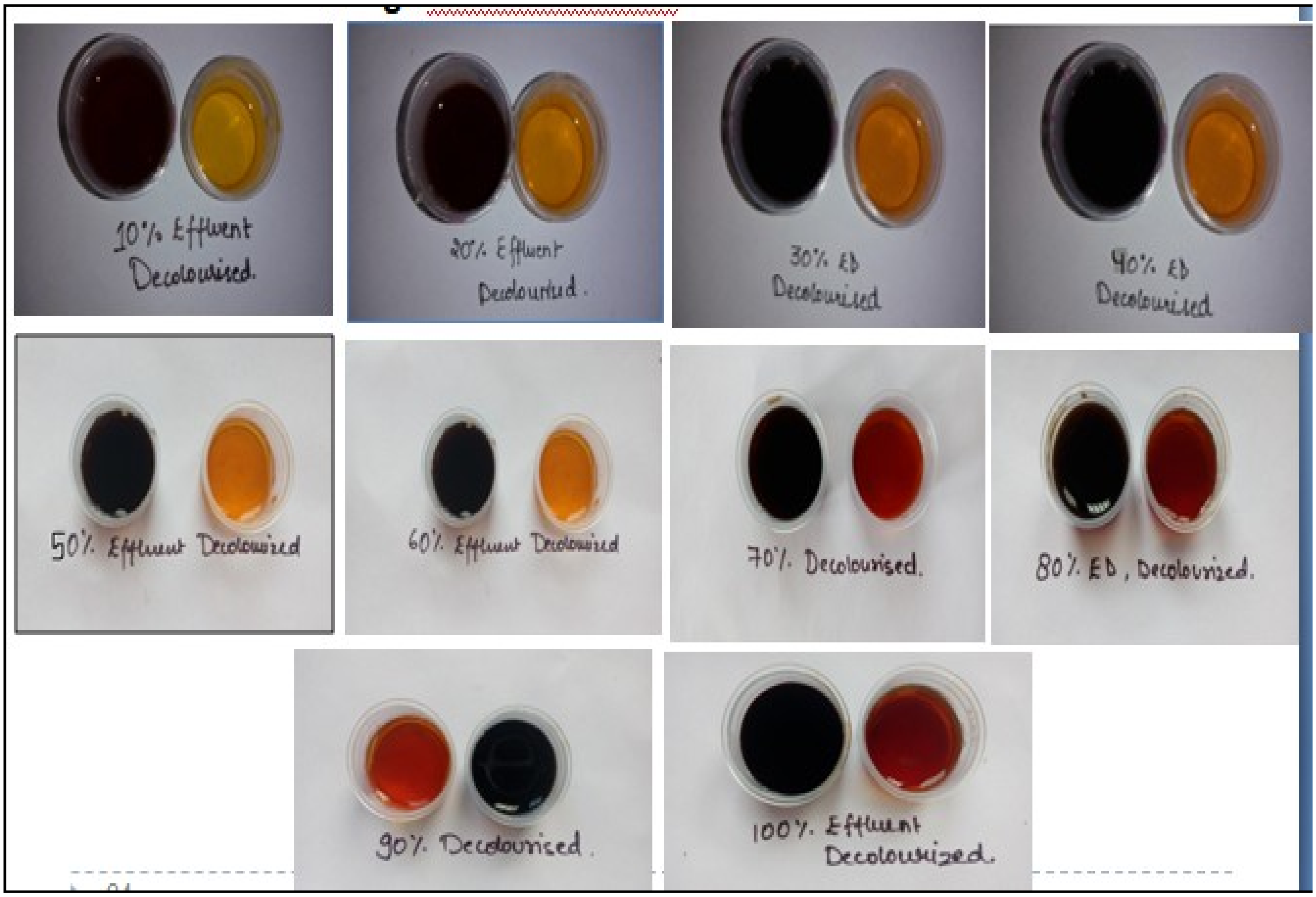

Fig. 3: Spent wash before and after treatment

The results from batch 2 column studies when compared showed that better results were obtained for bagasse and soil combination with good removal efficiency of 82% for 40% v/v effluent concentration at bed height of 18.6 cm and flow rate 0.1 ml/sec. The bed shrinkage of 4.6% was observed after complete run. The process parameters of Batch 2 studies are shown in Table 4. The percentage decolorization and melanoidins concentration in all the reactors are shown in Fig. 4 and 5 respectively. The comparative colour of the spent wash before and after treatment in batch 2 is depicted in Fig6.

Table 4: Process Parameters of Batch 2

Batch 1	Output Flow Rate (ml\sec)	Bed Height After Treatment(cms)	Bed Shrinkage (%)	Residence Time (hrs)	Decolorization (%)
60:60:60	0.2	18	2.7	20	75
60:60:100	0.1	19	5	22	77
60:100:60	0.1	18.6	4.6	21	82
60:100:100	0.4	19.8	3.4	22	72
100:60:60	0.1	17.9	3.2	22	68
100:60:100	0.3	18.5	7.5	21	64.5
100:100:60	0.2	20.8	3.2	24	70
100:100:100	0.01	21.9	6.8	23	79

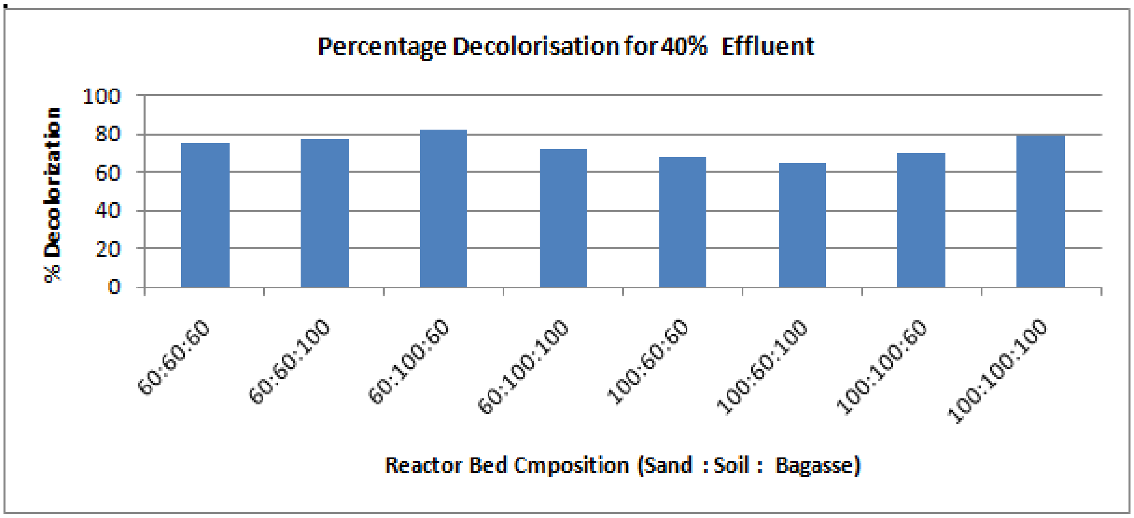

Fig. 4: Percentage Decolorization in Batch 2 reactors

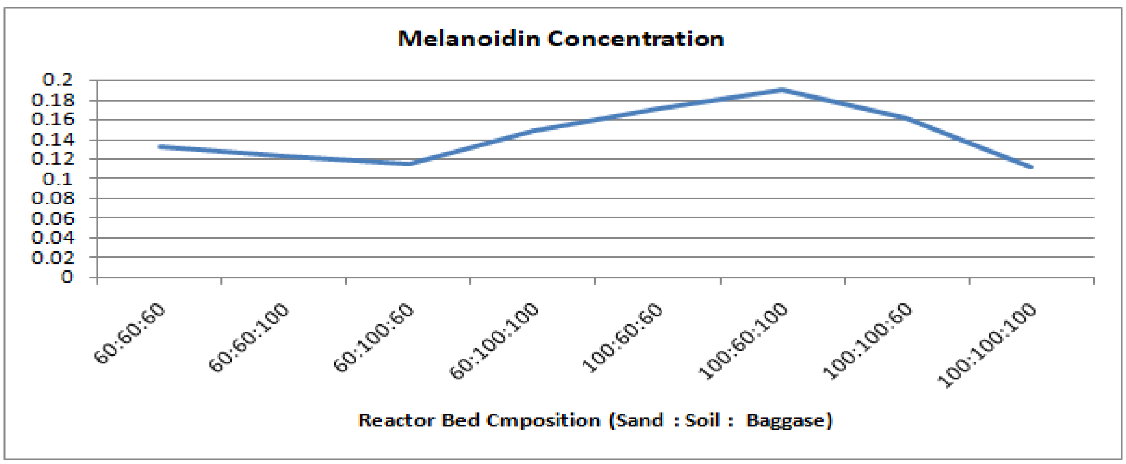

Fig. 5: Melanoidin Concentration in Batch 2 Reactors

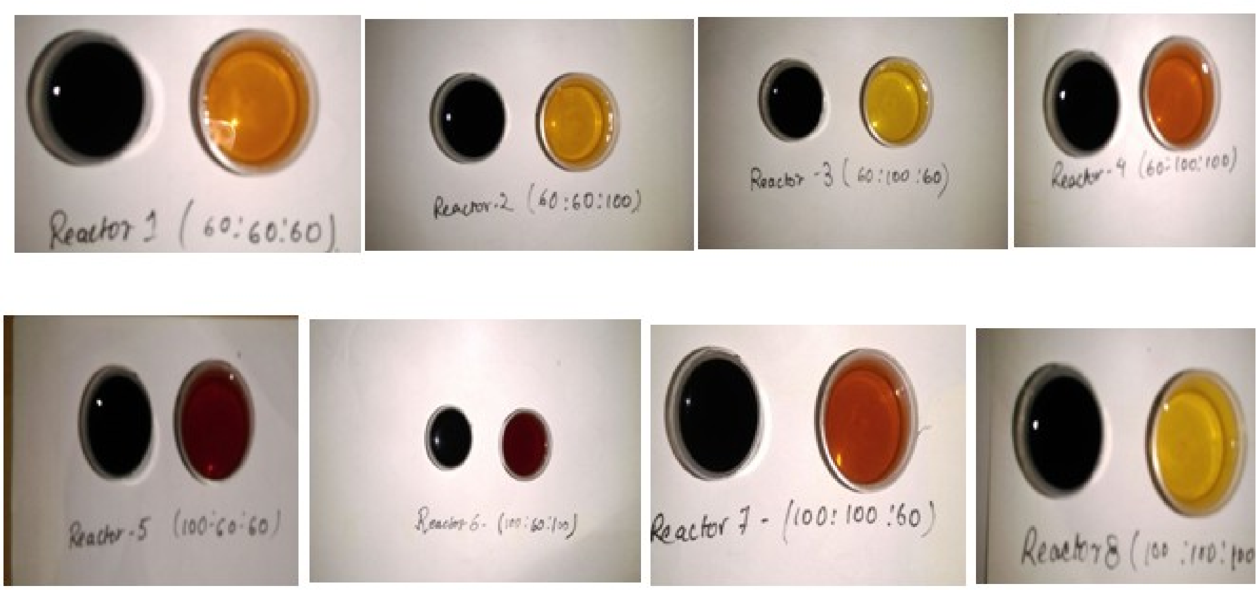

Fig. 6: Spent Wash Before and After Treatment

CONCLUSION:

This research is focused on implementing the cost optimized and practical methods, using natural decolorizing carriers for the treatment of biomethanated waste water released from the sugarcane molasses industry. .The extent of color removal was studied in packed bed reactor studies using natural agents to find out the most preferable combination. Through this study, the attempts were made to optimize the reactor and process parameter such as reactor bed height, bed shrinkage, input and output flow rates to achieve the maximum color removal. The set of Packed Bed reactor was prepared from soil, sand and readily available bagasse which is leftover residue after sugarcane juice extraction and their performance was compared by varying parameters like reactor bed composition, pH of effluent, dilution of biomethanated distillery effluent and flow rate of the effluent across the bed. The parameters like output flow rate, bed height, bed shrinkage and residence time were calculated after treatment and graphical interpretation was done using the experimental results. Using the applied method, it was possible to remove colour of treated effluent to the extent of 87%for 40% v/v effluent dilution. The results from column studies when compared showed that better results were obtained for bagasse and soil combination with good removal efficiency of 82% for 40% v/v effluent concentration at bed height of 18.6 cm and flow rate 0.1 ml/sec. The bed shrinkage of 4.6% was observed after complete run.

Thus, the experimental data proves that soil and bagasse combination can be used effectively for colour reduction from distillery effluent. Further these low cost natural carriers can be used at industry level for treating the melanoidins from molasses spent wash. Also the system will greatly enhance the soil quality.

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