DEVELOPMENT OF AN ADSORPTIVE MATRIX FOR DECOLOURISING TEXTILE EFFLUENTS

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ABSTRACT

Activated carbon, maize cob peat, cowdung, chemically derived cellulose fragments and compounds have been evaluated for adsorptive properties and exhibited a capacity to remove colorants from dye solutions and textile factory effluents. These matrices have been applied singly and combined in various mixtures to select an optimum treatment mixture for effluents. While effluent that has been maximally treated with only activated carbon or maize cob peat still possessed a residual faint colour, the application of an optimum mixture of them and cowdung scrubbed tested effluents free of colour. The efficiency of colour removal was rendered as decreases in the absorbance of effluents as they flow through a succession of glass columns packed with the different matrices. Decoloration efficiency depended on the format in which the components of the optimum mixture were presented in addition to the source of carbon and the particle size of all components. The cellulosic materials exhibited selective adsorption and are only preliminarily described.

INTRODUCTION

Environmental protection requires that factory effluents be treated to bring their quality within regulated standards before such effluents are discharged into the environment[1-3]. With particular reference to textile factories, the dark colours of effluents that issue from factory drains into gutters and other city drainage systems in Nigeria indicate that effluents are either untreated or insufficiently treated before they are discharged[4]. This situation creates a relevance for cheap and efficient effluent treatment materials and methods, not only for the textile industry but for all effluent producing industries. Pollution control practices aim at the removal of objectionable materials and pollutants from effluents by precipating, filtering, sieving or adsorbing them out of the effluents. These processes concentrate the pollutants for easy removal and disposal. This article presents an approach to the removal of pollutants that exhibit objectionable colours in effluents relying on inexpensive materials and procedures.

Activated carbon is regularly employed in trickle filtration systems to remove coloured pollutants from factory effluents[5-7]. It is, however, rather expensive when applied as a sole treatment matrix. The evaluation of cheap sources of charcoal for this application has been reported[8] as also that of maize cob peat[9] and cowdung[10]. Presently we are presenting the combination of these matrices to achieve the removal of colour from textile factory effluents. The capacity of cellulosic materials developed for the purpose highlighted in this article is also reported therein.

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EXPERIMENTAL

Materials

All reagents used in this investigation were of analytical reagents grade; all water used was distilled water and other materials were obtained as described below.

Activated carbon

Charcoal obtained by carbonising mango and acacia woood was activated with HCl as described elsewhere[8,9]. The carbon was then pounded and separated into a range of particle sizes (0.15 - 2.00 mm) using the Endocott set of sieves, model BS 410/1986. Each particle size was stored separately in a stoppered bottle in a desiccator for use as required.

Maize cob peat

Maize cobs were tenderised by soaking in water in a large glass trough for six months. They were then flushed and washed to remove green algae and allowed to dry in air. They were pounded with a mortar and pestle and sieved into the range of particle sizes 0.15 - 2.00 mm using the set of sieves. These were stored separately in stoppered bottles.

Table 1: Sources and characteristics of textile effluents

Sample	Source	λ_{max}	A_{max}
A	Gaskiya Textile Limited, Bompai, Kano	470 580	0.61 0.66
B	Zaria Industries Limited	610	0.48
C	United Nigeria Textiles Limited, Kakuri, Kaduna.	600	1.99
D	Pool of A, B and C	490 600	0.60 1.22

Table 2: Trends in effluent A absorbance after emerging from columns

Matrix	Absorbance	Ranking
Carbon	0.19	
Maize peat	0.29	
Cowdung	0.00	
Blend of 3	0.21	
CMD	0.22	
CDM	0.19	
DCM	0.24	
MCD	0.17	Optimum
DMC	0.20	
MDC	0.22	
CD	0.30	
MD	0.32	

Cowdung

The cowdung was dried, pounded in a mortar and pestle, sieved also as described earlier[9,10] and the particle sizes stored in separate stoppered bottles.

Table 3: Particle size effect on effluent decoloration by maize cob peat.

Sieve mesh (mm)	Absorbance	Ranking
0.150	0.355	most adsorbing
0.250	0.358	
0.300	0.385	
0.355	0.395	
0.425	0.398	
0.500	0.411	
0.850	0.418	
1.18	0.421	
1.40	0.436	
1.70	0.436	
2.00	0.438	least adsorbing

$A_{max} = 0.60$

Cellulosic materials

cotton wool, obtained from Zaria Industries Limited, was hydrolysed in 40% aqueous nitric acid and the product precipitated and filtered out, washed and dried in air (Matrix CD). Dry maize cobs were cleaned by brushing off fibres and hydrolysed in 40% nitric acid; the precipitate was filtered out, washed, air-dried and stored as matrix MD[11].

Textile effluents

Textile effluents were collected off the drains of their generating factories as indicated in Table 1. A pooled sample was obtained by mixing up the samples from various factories. The samples were letter-coded as shown in Table 1 only for purposes of this article. The effluent samples were stored, when necessary, inside a refrigerator in stoppered polythene bottles.

Characterisation of effluents

To characterise an effluent, its uv-visible spectrum was scanned using the Unicam SP 800 uv-visible spectrophotometer and the wavelength of maximum absorption (λ_{max}) of the colourants present in it determined. The absorbance, A, at λ_{max} was also determined for the unprocessed effluent. These characteristics are presented in Table 1.

Testing for colour removal

To investigate whether a test matrix was capable of removing colourants from an effluent, the matrix was packed in glass columns of 1.0 cm internal diameter, 5g per column, and conditioned in water for elution. 30 cm^3 of the effluent to be investigated, after characterisation, was passed through the column at a rate of 1.5 cm^3 min^{-1} and the effluent absorbance (A) at λ_{max} measured and compared with that of the unprocessed sample. Typical results are presented in Table 2 for various matrices tested on effluent A.

Particle size studies

Each column in a set of 11 was packed and conditioned with a different particle size of the same matrix. 50 cm^3 of effluent A was passed through each column at a rate of 1.5 cm^3 min^{-1} after confirming its absorbance at 580 nm. The absorbance was measured again for the effluent collected from each column and the values compared for the various particle sizes. A typical result is presented in Table 3 for maize cob peat. Effluents other than effluent A behaved similarly when tested on maize cob peat or the other matrices.

Investigation of matrix combinations

The effect produced by combining the matrices was investigated by selecting the optimum particle size of each matrix and repeating the procedure for testing colour removal, as reported already, on various combinations of the test matrices. Combinations tested included a mixture in which equal masses (2.0g) of carbon (C), maize cob peat (M) and cowdung (D) were blended together; other combinations introduced these matrices as separate layers overlying one another in the column following the sequences CMD, CDM, DCM, MCD, DMC and MDC. The results are presented in Table 2.

An arrangement in which each component matrix was further divided into thin layers of 0.5 g was also investigated and is discussed later.

The cellulosic matrices

The matrices, CD and MD, derived as reported previously from cotton wool and maize cobs respectively, were investigated for colour removal from effluents using the procedure previously described. The results are included in Table 2 and discussed later.

Testing efficiency of decoloration

The capacity of the combined matrix to remove colour from effluents was investigated by passing 50 cm^3 of each effluent through a series of columns, each packed and conditioned in the optimum format containing maize cob peat (2.0 g) as a single layer at the bottom followed by a layer of activated carbon of the same mass overlain by a 2.0 g layer of cowdung. The absorbance of the effluent stream was measured between columns and compared with that of the untreated effluent. The results are discussed later.

Matrix regeneration

The columns which have become saturated in use were regenerated by flushing each continuously with water flowing at a rate of 1.5 cm^3 min^{-1} and collecting the issuing effluent for absorbance measurements. The result is discussed later.

RESULTS AND DISCUSSION

The effluents investigated in this study were characterised by dark colours and a range of suspended particle densities. The intensities of colour imparted by the effluent streams from which these samples were obtained, to city drainage, particularly in Kano and Kaduna capital cities, indicate that factories do not treat their effluents adequately before discharging them.

The capacities of activated carbon, cowdung and maize peat to remove colour from effluents have been reported[8,9,10] and a suggestion that they could be incorporated into effluent treatment systems has been made. Particularly the advantage of including cowdung in a decolourising matrix has been demonstrated[10]. The results presented in Table 2 confirm that the inclusion of cowdung improves the adsorptive capacity of the mixed matrix tested. The format in which the bed of cowdung overlies the other components is also shown to exhibit greater colour reduction than the other formats. An attempt to reduce the thickness of alternating layers of components, down to 0.5 g, also yielded poorer results and is not recommended.

While the cellulosic materials demonstrated some adsorptive chromatographic properties (Table 2), the retention of colourants in them was not suitable for the arguments of this article. They are, however, being evaluated for other chromatographic applications as they both permitted the separation of dye components in mixed solutions.

The colour removal was observed to become more efficient as the particle size of adsorbents decreased. The advantage of intensified adsorption needed to be compromised at smaller particle sizes of adsorbent matrices because the matrix became impervious and pumping was required to sustain effluent flow through columns. To avoid pumping and associated difficulties, the determination of colour removal efficiency was conducted on matrix particles at 0.5 mm sieve pore size.

When the same 50 cm^3 of an effluent was passed successively through a cascade of columns, it required four columns to attain zero absorbance at λ_{max} for all the effluents tested. Compared to the efficiency of the individual matrices, the combined matrix has a similar efficiency but yields a cleaner effluent after treatment and is recommended.

Large volumes of water were consumed to scrub used columns free of colour and yield washings having zero absorbance. For example it took 450 cm^3 of water to clean up a 6.0 g matrix column which had become saturated by receiving excessive load of effluent A.

CONCLUSION

Activated carbon, maize cob peat and cowdung may be combined to achieve an inexpensive treatment of textile effluents to remove colour.

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