Studia Geotechnica et Mechanica, Vol. XXVIII, No. 2–4, 2006

TECHNICAL NOTE

PRODUCTION OF A PORTABLE BIOFILTER UNIT FOR THE REMOVAL OF ODOUR AND COLOURS FROM WASTEWATERS

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1. INTRODUCTION

Odours have been rated as the first concern of the public relative to the implementation of wastewater treatment facilities. Within the past few years the elimination of odours has become a major consideration in the design and operation of wastewater collection, treatment and disposal facilities, especially with respect to the public acceptance of these facilities. In many areas, projects have been rejected because of the fear of potential odours [10]. Odours in wastewaters are usually caused by gases produced by the decomposition of organic matter. Fresh wastewater has a distinct, somewhat objectionable, odour which is less objectionable than the odour of septic wastewater. The characteristic odour of staleness of septic wasterwater is that of hydrogen sulfide, which is produced by anaerobic microorganisms that reduce sulfates to sulfides. Industrial wastewater may contain either odorous compounds or compounds that produce odours during wastewater treatment. The importance of odours in human terms is related primarily to the psychological stress they produce rather than the harm they do to the body. Offensive odours can cause poor appetite for food, lowered respiration, nausea and vomiting and mental perturbation [9]. In extreme situations, offensive odours can lead to the deterioration of personal and community pride, interfere with human relations, discourage capital investment, lower socioeconomic status and deter growth. These problems can result in decline in market and rental property values, tax revenues, pay rolls and sales [9].

Contamination of water bodies with coloured effluents reduces aesthetic value of a typical surface water. For many miles evidence of pollution is obvious from the colour of river water polluted with dye stuff effluents [8]. The removal of this dye could reduce the toxicity of the dye stuff effluent to Nigerian macrobenthic invertebrates [7].

Fresh wastewater is usually grey; however as organic compounds present are broken down by bacteria, the dissolved oxygen in the wastewater is depleted to almost zero, the colour changes to black. This colour is unattractive and repulsive. In this condition, the wastewater is said to be septic or stale. Several methods for colour and

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odour removal include polymer coagulation, cation precipitation, ion-exchange, high-energy radiation and carbon adsorption. Some of these methods are often expensive, hence are cost prohibitive. The aim of this work therefore is to utilize the adsorptive property of some local raw materials to fabricate a low-cost biofilter that will remove colour and odour from most wastewaters.

2. MATERIALS AND METHODS

The packing materials used for the fabrication of the biofilter are paper pulp and montmorillonite clay. Pure white paper pulp was obtained from Star Paper Mill Company, Owerrenta, Abia State, while montmorillonite clay was obtained from Okigwe Clay Deport, located at Okigwe, Imo state, all in Nigeria. The montmorillonite clay was activated by heating at 200 °C for 3 hours. Cooled, then ground to fine powder the powder was sieved, using a set of standard sieves. The wastewaters used for this work were raw, untreated domestic, industrial and institutional effluents of grey, black and brown colours, respectively. They were collected in sterile 250 cm^3 plastic bottles, cooled in ice bath and filtered within 4 hours of collection. Sometimes a few drops of sulfuric acid were added as a preservative for samples for grease analysis.

The biofilter was fabricated with activated clay and pure white paper pulp in the ratio of 2:3 ($^{wt}/_{wt}$), packed in a glass column of an internal diameter of 10.0 cm and the height of 75 cm for the laboratory outfit or an aluminum column of an internal diameter of 30 cm and the height of 120 cm for the field demonstration. Clay formed the base packing and paper pulp was laid on the top. Then 2 dm^3 and 10 dm^3 of distilled water were allowed to drain out through the glass and aluminum packed columns to displace air bubbles. The effluent samples were analysed before and after filtration. Each biofilter unit was run for 3 hours each day for 21 days. The effluent was allowed to flow freely under gravity, from a reservoir in the laboratory. The wastewaters were analysed before and after filtering through the biofilter. The turbidity was determined spectrophotometrically at a wave length of 620 μm. The other physicochemical characteristics analysed were: BOD_5, TSS grease and ammonium nitrogen. These determinations were done using standard methods for the examination of water and wastewaters [1].

3. RESULTS

The different packing materials used to fabricate the biofilter employed in this study reduced the turbidity of the different effluents studied. Montmorillonite clay alone reduced the turbidity of domestic effluent by 97.4%, industrial effluent by 98.9% and institutional effluent by 97.9%, pure white paper pulp reduced the turbidity of the same effluents by 95.4%, 95.3% and 96.4%, respectively (table 1). Both packing materials

Table 1

Effect of different packing materials on turbidity and colour of wastewater

Wastewater montmorillonite clay						Pure white paper			Pulp
Type of wastewater	Initial turbidity	Final turbidity	Reduction (%)	Initial colour	Final colour	Final turbidity	Reduction (%)	Initial colour	Final colour
Domestic wastewater	1.3	0.03	97.4	grey	colourless	0.06	95.4	grey	colourless
Institutional wastewater	1.4	0.03	97.9	brown	light brown	0.05	96.4	brown	light brown
Industrial wastewater	1.5	0.02	98.7	black	light brown	0.07	95.3	black	light brown

Table 2

The effect of combined clay and paper pulp (biofilter) on the turbidity and colour of different wastewaters

Type of wastewater (effluent)	Initial turbidity	Final turbidity	Percentage reduction in turbidity	Initial colour	Final colour
Domestic wastewater	1.3	0.01	99.2	grey	colourless
Institutional wastewater	1.4	0.02	98.6	brown	colourless
Industrial wastewater	1.5	0.01	99.3	black	colourless

Odour before filtration = objectionable.
Odour after filtration = less objectionable.

removed the colour of the effluent and produced a rather odourless effluent. The combined materials now in the column reduced the turbidity of the different effluents tested. The turbidity of domestic effluent was reduced by as much as 99.2%, that of institutional effluent was reduced by 98.6%, while that of industrial effluent was reduced by 99.3%. After filtration the resultant effluents were almost colourless and most of the objectionable odours were removed in all cases (table 2). The results of the physicochemical analyses done on the different effluents before and after filtration are shown in table 3. The results showed that the biofilter reduced the BOD_5 of industrial effluent by 98.6%, the total suspended solids (TSS) of the same industrial effluent were reduced by 99.4% and ammonium nitrogen content was reduced by 98.5%.

4. DISCUSSION

Biofiltration is an emerging energy-efficient technology for the control of volatile organic compounds (VOCs). It has been extensively used in Europe and the Americas for the control of odours from wastewater treatment facilities, composting facilities and other odour-producing operations. Odour is caused by volatile substances and dissolved gases; usually organic matter causes the effluent to be septic. Hydrogen sulfide which reduces sulfate to sulfide is responsible for a septic nature of wastewater. Compost biofilters are known to be 83–99% effective in removing hydrogen sulfide and several simple aromatic compounds [2]. Filed-scale use of biofilter to remove odorous compounds and methane from landfill gas during landfill mining also has been reported [4].

Colour change, a physical property, is usually due to the decay of organic matter and it varies from grey to black, when the organic compounds have been broken down by bacteria thereby bring the dissolved oxygen to zero. Colour in domestic effluent is often caused by organic extracts from vegetables and other plant extracts. Sometimes there is direct disposal of synthetic paints or paint materials of different colours into domestic, industrial and institutional effluents. The use of our biofilter, fabricated from local raw materials, clay, pure white paper pulp and sometimes wood shavings/dust to remove colour and odour marks a clear application of biofiltration and bioconversion technologies in the control and management of domestic, industrial and institutional effluents. In aquatic environment, these effluents generally present a peculiar problem because of their colour, odour and turbidity. The biofilter reduced the turbidity of different effluents by 98–99% (table 2). A reduction of 98.6, 99.4 and 98.5% respectively was achieved for BOD_5, TSS and ammonium nitrogen (table 3). The ability to reduce biological oxygen demand and to remove colour and odour from effluent is attributed to the adsorptive property of the cellulosic material present in paper pulp. At high temperatures volatile materials are removed from clay, leaving clay of large surface area. Large surface area is important in adsorption and decolourization since both are surface phenomena. The ability of clay to reduce turbidity was observed while studying the mechanism of palm oil bleaching using activated montmorillonite clay, so both pure paper pulp and clay acted as adsorbents in the biofilter unit. The use of these local raw materials, i.e., paper pulp, wood shavings/dust and clay, which in themselves constitute bulk solid waste, requiring management is advocated. The production of a portable unit for the purification of drinking water based on local raw materials, mostly wood shaving, had been reported [3]. These raw materials, i.e., wood shavings, peat soil and other media, were readily available. The treatment process which occurred in our biofilter media consisted in physical filtration and adsorption, chemical adsorption, ion exchange and biological transformations.

The performance of our biofilter unit with respect to its ability to remove odour and colour from sources is summarized in table 3. The reduction is, on an average, 98.5% of the parameters that cause odour and colour in wastewaters.

Table 3

Average performance of the biofilter unit with respect to its ability to remove odour

Parameters analyzed	Influent	Effluent	Percentage reduction
BOD_5 (mg/dm^3)	1452	20	98.6
TSS (mg/dm^3)	490	3.3	99.4
NH_2-H (mg/dm^3)	680	10.5	98.5
Grease (mg/dm^3)	43.7	0.8	98.3
Total bacteria (CFU/cm^3)	1.9×10^5	1.3×10^3	96.5

Wastewater used is industrial wastewater, influent = before filtration, effluent = after filtration.

5. CONCLUSION

The use of our biofilter to remove odour, colour and to reduce turbidity centres around two important biological processes: bioconversion and filtration. Bioconversion in the sense that the raw materials used, wood shaving/dust, paper pulp and clay, constitute bulk solid waste which in themselves need management but were here being converted into good use. These raw materials were readily available and cheap to procure. Their use therefore in the fabrication of the biofilter unit that removed colour and odour makes the operation cheap, affordable, and improves the quality of the environment.

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