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A dewatering treatment for oily sludge using geotextile filters

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ABSTRACT: It is well known that waste from the petroleum industry has a high environmental impact. Conventional systems for oil-water separation are used to mitigate the contamination potential of the effluents. The oily slurry formed on the bottom of these separation systems has high concentration of contaminants making the disposal of this slurry is an environmentally hazardous practice. Normally it is disposed of in tanks or landfills after removal from an industrial plant. The present work presents an alternative treatment for this oil slurry to mitigate the environmental impacts and reduce the cost of disposal. Basically, the technique consists of using drying beds with geotextile filters to reduce the water content in the slurry and obtain a less contaminated effluent. Some laboratory tests were carried out to simulate the drying system. Four types of filters were analyzed: two non-woven geotextiles, one woven geotextile and a sand filter.

1 INTRODUCTION

Oily effluents produced in the petroleum production chain are treated primarily using traditional oil-water separation systems (OWS) to minimize the oil levels and allow the oil to be recuperated and the effluent treated. The equipment that tends to be used for this type of treatment is the API oil-water separator. This is basically a rectangular tank through which the effluent flows at low speed, with laminar flow. As this happens, oil droplets rise to the surface and the solids settle on the bottom. At the OWS outlet, the oil is skimmed off the surface, while the slurry is removed from the bottom, channeled into a ditch and pumped out. There are currently other types of gravity-based separators that are an improvement on the API type, like the parallel plate interceptor. This separator is filled with plates that accelerate the formation of large oil drops at the surface, improving the effectiveness of the separation and reducing the size of the separator. While an API separator can supply effluents with 40 to 150 ppm oil, the parallel plate separator can supply one with 20 ppm. However, the API is around three times cheaper, which explains why it is often preferred (Costa et al, 2003).

This method of handling oil is still highly unreliable, and leads to wastewaters with high oil levels and an oily slurry with a high water content, added to which the final disposal of this waste is environmentally hazardous given the high level of contaminants. The removal of water from this slurry to make it easier to dispose of has been the subject of much work by people working at treatment plants.

It would be advantageous if alternative methods could be found for recuperating this slurry: it would minimize environmental impacts, and, furthermore, the slurry itself is a source of energy that is often wasted because it is badly reused. This issue therefore needs to be researched so guidelines can be set for optimizing the use and destination of this waste, which could also help the monitoring done by the relevant environmental agencies.

This work proposes a method for treating oily slurry, consisting basically of a dehydration process using drying beds with geotextile filters.

2 OILY SLURRY

With energy needs so heavily dependent on oil and its derivatives, it becomes imperative that the threats posed by this model of development be recognized. This being the case, the waste that is produced in fuel production processes has started to be a cause of concern, one which until recently had not received attention. Some of these waste materials are sludge and slurry from oil, and especially from lubricants. Until recently, this sludge/slurry was stored in tanks or discharged into landfills almost arbitrarily, even in developed countries, since there was no specific environmental legislation on the matter. To assess the magnitude of the threat that the production of sludge/slurry represents, it is necessary to discover at which stages of the production process it is produced and what its basic characteristics are. In this way, the critical point of each unit can be identified and a strategy for waste management can be drawn up (Braile, 1999). This first step is fundamental, especially since some types of sludge/slurry can be reused, recycled, incinerated, co-processed and even treated.

3 PROPOSED TREATMENT OF OILY SLURRY WITH A DRYING BED

A method is proposed here for treating oily slurry before it is finally discharged, with a view to reducing the environmental damage and direct costs involved in the disposal process. The basic assumption of the proposed treatment is a new separation of the water from the sludge, with the following aims: to obtain water with a contamination level that allows it to be treated; and to obtain dehydrated slurry that can be reused in the co-processing of the cement or ceramics industry. Even if the slurry cannot be used in the co-processing, the dehydration would reduce the volume of the final waste to be discharged, minimizing the environmental impacts and costs involved.

The process chosen consists of removing water from slurry using a system similar to a drying bed used for dehydrating sewage sludge in open air (Campos, 1999).

The drying bed is a rectangular unit where the water content in the sludge is reduced naturally by drainage and evaporation (Figure 1). Drainage is the process that most contributes to removing water from sewage sludge. In a conventional drying bed, the sludge (a 30–60 cm layer) is placed on a layer of sand filter (15–20 cm thick) on top of which is a protective layer of bricks. Beneath the sand is a layer of gravel and a perforated tube to collect the drained fluid.

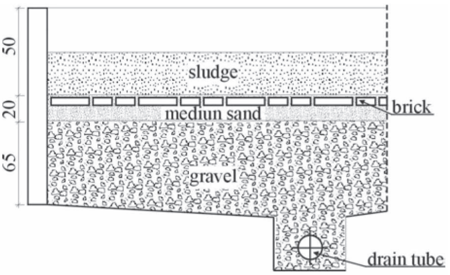


Figure 1. Cross-section of a drying bed for sewage sludge using granular filters.

The drying bed is operated in batch mode, and the cake retained on the filter needs to be removed before a new layer is applied if the process is to work well. The process for dehydrating oily slurry, however, proposes substituting the sand filter layer and brick covering for a geotextile layer (Figure 2).

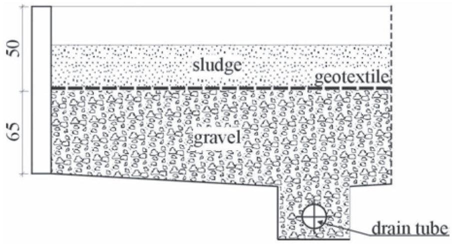


Figure 2. Cross-section of the proposed drying bed using geotextile layer.

4 TESTS

4.1 *Aims*

An experimental campaign was designed with the aim of checking the performance of a drainage system representing a drying bed for dehydrating oily slurry. The basic aim was to analyze the water loss in the slurry, the contamination level in the drained fluid and the drainage capacity of the filter with time. Four different filters were used, three of which were synthetic (G1, G2 and G3) and one granular (sand), as shown in Table 1. The sand was composed by 71% of coarse sand, 26% of medium sand and 3% of fine sand and its dry specific weight was 16,3 kN/m^3. The oily slurry was collected from a lubricants plant in the city of Rio de Janeiro. Table 2 presents its basic composition.

Table 1. Geotextile properties.

Geotextile	Polymer*	Fabric	Thickness **(mm)	Opening size ***(mm)
G1	PET	non-woven	2.6	0.12-1.17
G2	PP	non-woven	2.8	0.11
G3	PP	woven	0.4	0.8

* PP = polypropylene; PET = polyester.
** Standard procedures: ABNT NBR 12569 (under pressure of 2.0 kPa) for G1 and G2 and ASTM D-5199 (under pressure of 2.0 kPa) for G1.
*** Standard procedures: ASTM D-4751 for OP-30 and 4004 and AFNOR G 38017 for G-300.

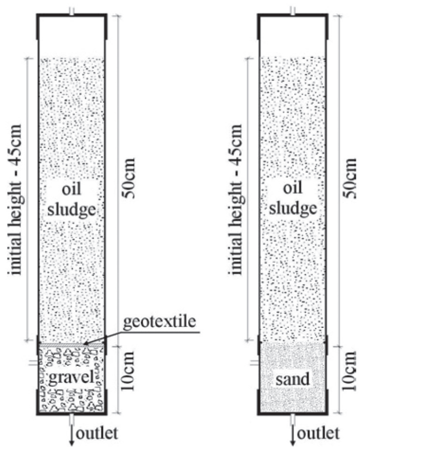
4.2 *Methodology*

The experimental methodology consisted of making the water contained in the oily slurry drain through the falling head filter, utilizing column filtration permeameters (Figure 3). The filtration columns were made of PVC, had a 10 cm diameter and were 60 cm high. For the tests with geotextile filters, the base of the columns had a 10 cm washed gravel bed upon

Table 2. Oily slurry analysis results.

Analysis*	Value
density (g/mL at 20°C)	1.04
pH	6.9
oil and grease (% – weight)	8
water (% – weight)	82
solids (% – weight)	10

*Measured using Standard Methods (APHA, 1992).



(a) (b)

Figure 3. Schematic diagram of the configuration of the permeameters utilized in the tests. (a) with a geotextile filter; (b) with a sand filter.

which the geotextiles were placed. For the sand filter, the bottom of the column was made up of a 10 cm layer of washed sand. After they were assembled, 3.53 L of slurry, corresponding to a 45 cm-high column above the filter, was poured into the top and the tests started to be monitored. The section below the slurry/filter interface was open to the atmosphere. Measurements of the flow rate, hydraulic head and COD levels in the drained fluid were made, as well as the water content of the slurry. Knowing the COD makes it possible to estimate the level of oil and grease, since this represents the level of organic compounds present in the sample (Hach – APHA standard method, 1992).

The preliminary tests presented were done in two stages. In the first (stage I), the water was left to drain out of the slurry for around three weeks. In the second (stage II), the cake retained in stage I was removed and a new volume of slurry was introduced into the permeameter, without changing the filter. This second stage lasted around one week. The tests were carried out under an average room temperature of 22°C.

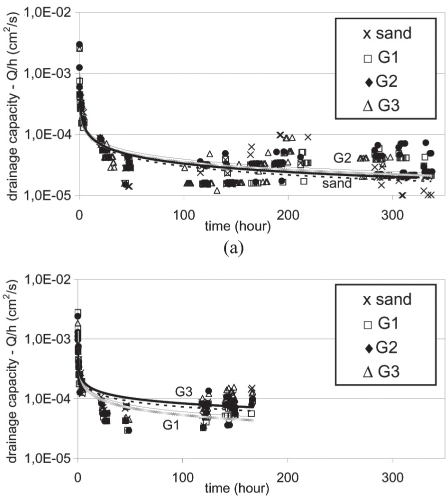


Figure 4. Variation of the drainage capacity of the filtration column with time; (a) stage I; (b) stage II.

4.3 *Results*

Figure 4 presents the variation of the drainage capacity of the filtration column, expressed by Q/h, where Q is the flow rate and h is the hydraulic head, with time. The reduction in the volume of slurry after the end of the tests is presented in Table 3. The reduction in the volume is expressed as $(V_0 - V_f)/V_0$, where V_0 is the initial slurry volume and V_f is the volume at the end of the test.

Table 3. Reduction in the volume at the end of the tests.

Filter	Reduction in volume $(V_0 - V_f)/V_0$ – %	
	Stage I (3 weeks)	Stage II (1 week)
OP-30	46.7	32.2
G-300	47.7	36.7
4004	46.9	41.1
Sand	46.2	41.8

Table 4 shows the variation in the water loss from the slurry at the end of the test, expressed by $\Delta V = (w_0 - w_f)/w_0$, where w_0 is the initial water content in the slurry and w_f is the water content at the end of the test.

Table 4. Variation in water content in the slurry after stage I.

Filter	Variation in water content $(w_0 - w_f)/w_0$ – %
OP-30	49.2
G-300	58.0
4004	50.4
Sand	46.8

Table 5 presents the organic load in the drained fluid, measured in COD.

Table 5. COD in drained fluid.

Filter	COD (mg/l)	
	Stage I (3 week)	Stage II (1 week)
OP-30	165	242
G-300	95	212
4004	167	252
Sand	134	249

4.4 *Discussion of the Results*

The drainage capacity of the column reduced with time during each stage of the test (Figs. 4a, b). The removal of the cake retained on the filter led to a recuperation of the drainage capacity of the column in stage II. This indicates that the reducing drainage capacity observed during the test is the result of the sedimentation of the solids in the slurry, forming the cake.

There was no significant overall variation in the performance of the filters as regards the drainage capacity of the system.

As regards the reduction in the volume, there was a considerable volume reduction of 46% to 48% over the initial slurry over the three weeks of test. In the second stage, after one week of test, this volume reduction also stayed very high (32% to 42%).

The variation in the water content obtained at the end of the first stage of the test was considerable, varying from a 46.8% reduction in the cake retained by the sand filter to 58% for the G2 filter.

The results from stage II indicated that the performance of the filters was recovered after their use in stage I, even though it was slightly worse. It was noticed that small differences were higher for non-woven geotextiles.

The low COD values obtained in the drained fluids indicate that the geotextile filters retain the oil and grease present in the sludge well, thereby generating an effluent that can be treated in the conventional systems that are already implanted in industrial facilities.

Furthermore, the humidity reduction contributes to its high calorific value of 18.1 MJ/kg – similar to cane waste: 18.9 MJ/kg and cuts of eucalypte: 19.6), which makes the treated oily slurry an alternative fuel raw.

5 CONCLUSIONS

In general, the results of the tests undertaken indicated a satisfactory performance of the treatment process proposed for oily slurry using drying beds.

The process of drying the slurry brought about a considerable reduction in its water content, greater than 47%. Consequently, a variation of more than 46% was obtained in the volume, considerably reducing the volume of the waste to be discharged. As regards the effluents, the system achieved a very satisfactory retention of oil and grease, allowing them to be treated conventionally.

Given the preliminary nature of the tests, it could be said that the performance of the four filters used (one geotextile fabric, two non-woven fabrics and sand) was similar. This therefore reinforces the feasibility of using geotextiles as filters for drying beds for this purpose. Furthermore, it was relatively easy to handle the geotextile filters, added to which there was a reduced volume of waste to be discharged at the end of the working life of the geotextile, as compared to the sand filter.

The results further indicate the possibility of reusing the filters after the cake retained on them has been removed.

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