SLUDGE REMOVAL FROM SOME WASTEWATER STABILIZATION PONDS

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ABSTRACT

The study of sludge accumulation in the first ponds of 12 treatment plants under oceanic climate showed a mean rate of accumulation of 2.8 cm per year corresponding to 0.12 m$^3$ of sludge per inhabitant per year.

Desludging was required about operation periods of 6 or 7 years. Sludge removal by pumping after or without emptying water is the most convenient and with a mean cost of 40FF per m$^3$ the cheapest method. Mean desludging cost is eight times lower than mean investment cost. With regard to their agronomic characteristics stabilization pond sludges have a low fertilizer value because of their long maturation time.

KEYWORDS

Wastewater stabilization pond, desludging, technical and economical aspects.

INTRODUCTION

Wastewater stabilization pond are considered as a very convenient sewage treatment technique for wastewater from small rural communities (with a population of under 2,000). Racault et al. (1987) listed approximately 1,800 such treatment plants in France in 1987.

The success of this system is due partly to the low investment cost which is some 20-30% less than for traditional plants (Racault et al., 1987) and partly to the fact that it is simple to operate (AFBLB-CTGREF, 1978). The removal of sludge that has accumulated in ponds, in particular in the first one, is the most demanding of all the maintenance operations. It appears far in the future when the pond is first brought into service, and has as yet aroused very little attention.

As this type of treatment plant is now beginning to age, this seemed to be an appropriate time to look at the technical and economical aspects of this operation.

The present article contains a synthesis of the information obtained from some fifteen French departments.

SLUDGE ACCUMULATION IN PONDS

Investigations revealed that the decision to desludge a pond is usually taken because of sludge floating mats on the surface of the pond and unpleasant odours rather than as a result of any decrease in plant performance or of the excess amount of sludge that has accumulated.
Measuring the accumulation of sludge

Although the theoretical calculation of sludge production per caput (AFBLB-CTGREF, 1978) provides a means of estimating the volumes of accumulated sludge, only a direct measurement of the thickness of the deposits at different points can give an accurate knowledge.

Various methods are used to this end:

- a calculation of the difference between the total depth of the pond measured by pushing a metal rod down through the sludge to the water-tightness layer, and the depth of water measured by means of a disk fixed to a metal rod.

- a stick covered with a piece of cloth. The thickness of the sludge is estimated to correspond to the mark on the cloth.

- core sampling performed by pushing a graduated plexiglass tube (Middlebrooks, 1965) down to the layer of clay. The thickness of the layer of sludge can then be read directly off the tube.

This latter method seemed to be the easiest to implement. It provides measurements that are at least as precise as the echo-sounder method being developed at the present time by the CEMAGREF in Bordeaux (personal communication, 1988).

Rate of sludge accumulation

The measurements effected on accumulation of sludge show that it is not spread uniformly across the whole pond. Wind has no effect on the distribution of sludge deposits (Middlebrooks, 1965); but on the other hand it would seem that the geometry of the ponds is a decisive factor. Whatever the pond, there is a thicker layer of sludge at the inlet and near the outlet, as well as near embankments and in dead zones. Compact basins are characterised by irregular distribution over the remainder of the surface caused by the formation of channels. In elongated ponds, the distribution is fairly regular. The irregular deposits in compact ponds make it necessary to carry out additional measurements compared to elongated ponds before the volume to be extracted can be calculated correctly. This can also complicate the cleaning operation.

With regard to the dozen first ponds looked at in our research, each of comparable design and all lying under oceanic climatic conditions, the thickness of sludge accumulated in 1 year varied between 1.5 and 8.5 cm, with a median value of 2.8 cm corresponding to an accumulation of 0.12 m³ of sludge per inhabitant per year. These values can be compared to the ones reported by Gloyna (1971) and Schneiter et al. (1983) and obtained in different climatic conditions.

DESLUDGING

Frequency of desludging

The study showed that the decision to clean out a pond was taken for varying thickness of sludge corresponding to a volumetric loss in the pond of between 9 and 55% of the total volume (mean value 30%).

The period of operation before desludging varied between 3 and 10 years, with 50% of sample being cleaned out in less than 6 years. The arbitrary value of 10 years operational life before desludging was reached only in 3 cases.

Desludging methods.

29 of the 30 cleaning operations looked at, involved the recovery of liquid sludge and, with 2 exceptions, the pumping out of sludge deposits. In 65% of cases, the liquid sludge was removed after emptying water of the pond.

Recovery of sludge after emptying water.

This method, which was used for ponds of between 200 and 5,000 m², requires at first the by-passing and emptying of the pond that is to be cleaned.
In most cases, the sludge is then gathered in a slurry tanker but it can also be removed by a vacuum tanker. In one case, the sludge was removed with a mechanical shovel and in another it was removed manually by shovel.

In order to facilitate this operation, the sludge near embankments has to be scraped manually and diluted with the water remaining in the pond. This requires a work force of 4 or 5 people. The last few centimetres of sludge are difficult to remove and the suction pump often removes as much clay as sludge.

Recovery of sludge without emptying water.

Sludge is pumped out of the pond using a suction head 1.5 m in width mounted on a raft equipped with a connection linking the suction pipe to vacuum tanker (fig.1).

Fig. 1. Suction head

The raft is moved manually along cables stretched across the pond (fig. 2). This system makes emptying unnecessary but increases the volume of sludge because it is diluted by a factor of two. However, the dilution has one advantage for the removal of older sludge which may have a solids content of up to 35% (Carré et al., 1987). This method seems to be effective but particular care needs to be taken when cleaning the edges where vegetation may make it difficult to remove the sludge.

Fig. 2. Raft-mounted pump.
In two cases, the sludge was removed with a suction-dredger. This equipment, which was initially designed for the cleansing of lakes or harbour areas, is suitable for this purpose but the sludge is highly diluted as a result. It also requires the presence of intermediate storage ponds where the sludge must be stored before being used for agriculture.

Removal of sludge after drying out. This method was mentioned only once. It is difficult to dry sludge out in an oceanic climate and it takes at least 2 months, during which time the unavailability of the pond concerned may impair the quality of the effluent. The sludge is removed with a mechanical shovel or a bulldozer. The ponds must be checked after the machines have been at work to ensure that they remain watertight. There must be easy access to the ponds and the embankments must be sufficiently resistant, which is rarely the case.

Duration of desludging

Pumping out sludge may take from between 0.5 to 15 days per pond, with an average duration of 3 days. The two dredging operations lasted for 5 and 11 days respectively. This duration depends mainly on the volume of sludge to be removed, as well as the difficulties that are inherent to each individual plant.

Pumping sludge out using a slurry tanker after emptying water of the pond becomes more difficult as the operation progresses and takes 3 or 4 times longer than at the beginning because the sludge has a higher dry solids content.

DISPOSAL OF SLUDGE

Table 1 presents a synthesis of the agronomic characteristics of the sludge from the first ponds in 12 plants and compares them to other organic fertilizers.

<table>
<thead>
<tr>
<th></th>
<th>Stabilization pond sludges</th>
<th>Slurry*</th>
<th>Manure*</th>
<th>Liquid aerobic* stabilized sludges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids mg.l⁻¹</td>
<td>5.4-13.6</td>
<td>10</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>Volatile solids mg.l⁻¹</td>
<td>22.7-48.6</td>
<td>60-80</td>
<td>60</td>
<td>45-60</td>
</tr>
<tr>
<td>Kjeldahl nitrogen mg.g⁻¹ of TS</td>
<td>0.8-2.7</td>
<td>4-6</td>
<td>1-3</td>
<td>4.5-6</td>
</tr>
<tr>
<td>Total phosphorus as P₂O₅ mg.g⁻¹ of TS</td>
<td>0.99-2.2</td>
<td>2-5</td>
<td>0.3-2.5</td>
<td>4-8.5</td>
</tr>
<tr>
<td>Potassium as K₂O mg.g⁻¹ of TS</td>
<td>0.03-0.93</td>
<td>3-5</td>
<td>2.5-3.5</td>
<td>0.5-1.5</td>
</tr>
</tbody>
</table>

(*After Anred 1983)

The sludge has a high mean total solids content in particular much higher than the sludge from traditional sewage treatment plants but a low organic matter content because of the long maturation during its extended storage in the ponds. For the same reason the sludge content is low on nitrogen and phosphorus. The potassium content is comparable to the amounts found in other residual sludges.

Therefore the sludge is of little interest for agriculture especially because of the low availability for plants of the nitrogens and phosphorus forms. Given the geographical whereabouts of wastewater stabilization ponds in rural areas, the use of sludge for agricultural purposes nevertheless remains the most logical solution to dispose of these products.

COST OF DESLUDGING

This study has shown that the cost of desludging varies a great deal from one situation to another but that, generally speaking, the greater the volume of sludge to be removed, the lower the cost of removal/m³.

Prices demanded by firms can vary by as much as three times the lowest estimate depending on the method used. Almost half the operations cost under 40FF per m³. There is a vast range among the top prices.
The most competitive prices are to be found for the two. They vary from 19 to 85 FF, per m³ but in 60% of cases they do not exceed 40 FF per m³. Dredging is more expensive (75 and 98.50 FF) and more comparable to the only cleansing operation using a mechanical shovel which costs 78 FF per m³.

Manual sludge extraction remains the most costly solution at 192.40 FF per m³. The low cost of certain pumping operations can be explained by the use of council workmen and farmers. The latter lend out their slurry tanker and receive in exchange the sludge which they can then spread on their land. In this case, the cleansing operation costs approx. 30 FF per m³. However, this procedure is only feasible for small ponds. With cost of between 25 and 33 FF per m³ for sludge removal alone, the prices charged by dredging firms are no higher than the ones demanded by companies using pumps. However, most of these firms are based some distance from the treatment plants. This means that, in addition to the costs indicated above, there are very high transport costs for the equipment. Moreover, this technique requires the building of an intermediate storage pond. Finally these firms do not transport the sludge nor spread it over agricultural land, and this again increases cost.

For small volumes of sludge (20 to 500 m³) desludging represent a cost of between 1,562 and 20,500 FF at today's prices. For larger ponds, they may cost as much as 90,500 FF. In 8 cases out of 30 the cost exceeded 50,000FF.

An inspection of costs for 11 ponds (Table 2) shows that investment cost varies between 174 to 1,168 FF per caput (with a mean value of 500 FF) and desludging cost varies between 20 to 200 FF per caput (with a mean value of 60 FF), in the year of desludging.

<table>
<thead>
<tr>
<th>Location</th>
<th>L'Aigpillon</th>
<th>Bouin</th>
<th>Chauche</th>
<th>St-Aubin</th>
<th>St-Provaut</th>
<th>La Rabatel</th>
<th>La Tranche</th>
</tr>
</thead>
<tbody>
<tr>
<td>investment</td>
<td>2979,800</td>
<td>89,892</td>
<td>131,185</td>
<td>136,385</td>
<td>190,670</td>
<td>222,180</td>
<td>436,395</td>
</tr>
<tr>
<td>cost/desludge</td>
<td>50,000</td>
<td>45,000</td>
<td>10,900</td>
<td>31,000</td>
<td>35,000</td>
<td>80,000</td>
<td>2,500</td>
</tr>
<tr>
<td>cost/desludge</td>
<td>12.6</td>
<td>9.0</td>
<td>11.8</td>
<td>13.8</td>
<td>13.8</td>
<td>9.9</td>
<td>13.8</td>
</tr>
<tr>
<td>cost/desludge</td>
<td>2,550</td>
<td>1,135</td>
<td>250</td>
<td>400</td>
<td>600</td>
<td>400</td>
<td>2,500</td>
</tr>
<tr>
<td>cost/desludge</td>
<td>1,168</td>
<td>79</td>
<td>525</td>
<td>341</td>
<td>318</td>
<td>555</td>
<td>174</td>
</tr>
<tr>
<td>cost/desludge</td>
<td>19.6</td>
<td>39.6</td>
<td>43.6</td>
<td>77.5</td>
<td>58.3</td>
<td>200.0</td>
<td>30.4</td>
</tr>
<tr>
<td>Table 2</td>
<td></td>
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</table>

**TABLE 2 Stabilization ponds investments and desludging raw costs (rate of interest for the loans not included).**
CONCLUSION

Sludge accumulation in wastewater stabilization ponds is irregular and depends on pond geometry which varies greatly. Given a mean rate of accumulation of 2.8 cm per year in an oceanic climate, desludging of the first pond in stabilization ponds systems is usually required after operating periods of 6 or 7 years.

The removal of liquid sludge seems to be the only worthwhile cleansing technique. This technique involves the pumping up of the sludge after emptying water using a slurry or a vacuum tanker or without emptying water using a raft-mounted sludge pump or a suction-dredger. Desludging lasts about 3 days.

Total cost of sludge extraction and disposal varied from 22 to 192 FF m\(^3\). Pumping methods are the cheapest methods.

With regard to their organic matter, nitrogen and phosphorus contents of ponds sludge are of no real agronomical interest, although spreading on land is the best way of disposing of it.

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REFERENCES


