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3.6 Sustainable uses and method for water treatment plant sludges

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Abstract
Once Water Treatment Plant (WTP) for public supply is considered as an industry, it uses water as a source, chemicals and physics and biologic steps to treat the water and, obviously, generate waste, which is called as sludge. Most of these WTPs in Brazil use surface water as a source and a conventional complete cycle treatment type. The WTPs sludges are found mainly in clarifiers and backwash water filter. Unfortunately, most of Brazilian WTPs launches its sludge directly into water resources, without previous treatment, violating management practices and the Brazilian legislation. A solution for this sludge is to remove its water and after that, recycle the water removed and use the dried sludge in other activities, for example in ceramic production, in non-structural buildings and even to generate energy. This paper presents a natural and sustainable technology to dewater clarifiers WTPs' sludge and discusses possible uses for this processed waste.
Keywords:
Water Treatment Plant (WTP); Industry; Sludges; Dewatering; Systems; Drainage Bed (BD)

1 INTRODUCTION

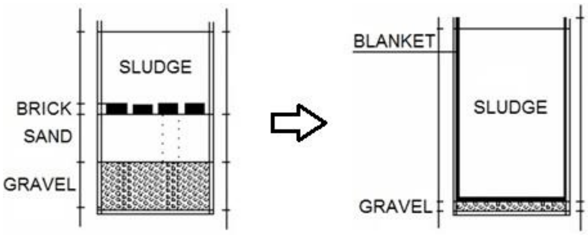
Water Treatment Plants (WTPs), which is a system to treat the water for public supply, for the reason of generating waste (sludges) with different characteristics, depending on the stream characteristics, the type of treatment (the type and amount of chemicals, etc.), is considered an industry. About this classification, the USA have published the "Clean Water Act" (PL 92-500), which establishes that WTP for public supply fall into industries classification and therefore should have its waste treated and disposed properly.

The act of thinking about treat WTPs sludges, due to its very fluid characteristic (1 to 5% of total solids), means to decrease its volume, which leads us to seek for possibilities to remove the portion of water from the content.

Dewatering systems for sludge in WTP, naturals or mechanicals, are essential for reduction of sludge volume and make its final disposal easier. Also, the efficiency of sludge dewatering depends on the required energy.

From researches carried out by Cordeiro [1], who developed a natural system of dewatering: the Drainage Bed – DB, and other studies conducted by Achon and Cordeiro [2], it was investigated the applicability and advantages of this system in comparison to other natural dewatering systems.

These studies with DB have been evolved with Barroso [3] and Achon et al. [4], who analyzed the influence of climate variables and realized that they are determinant during the phase of sludge drying. DB is a system that applies geotextile blanket as a filtering media, and it has more advantages when compared to other natural systems, due to its dewatering efficiency (drainage of free water), quality of the drained water and the possibility of drying the sludge by thermal processes (evaporation). This natural system was a result of an evolution of traditional drying beds, in which the filtering media is the sand. The Figure 1 shows this evolution described.



(a) (b)

Figure 1: Evolution from traditional drying beds (a) to drainage bed (b).

The aim of this paper is to show some sustainable dewatering methods and applications for WTPs sludges and the DB as an opportunity for WTP located in tropical countries due to results obtained with covered DB.

2 SUSTAINABLE DEWATERING METHODS

It is important to note that to this present paper the term sustainable dewatering methods consists of methods that do not require external/mechanical energy, but only natural one. Examples of these methods can be drying beds, bags and drainage beds (DB).

2.1 Drying beds

The traditional drying beds, as simply represented in Figure 1, is composed by three layers as a filter media: brick, sand and gravel. In some applications the brick layer is dispensed. To improve the filtering capacity, the sand layer is composed

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by two or three layers with variable granulometry with total thickness of about 0.3 m.

There are occasions in which the background of the drying bed is a waterproofing layer, however, traditionally, the background is the soil itself. The operation of these beds should be performed observing the complete drying of the sludge from one to another discharge, as well as the height of the layer dumped that, after being properly spread, it is important to respect the maximum height of 0.3 m. Some advantages and disadvantages of using traditional drying beds are presented in Table 1.

Table 1: Drying beds system: advantages and disadvantages [5].

ADVANTAGES	DISADVANTAGES
- Low initial cost when the cost of land is low. - Low necessity of operation. - Low power consumption. - Low necessity of chemical conditioning uses. - High solids concentration.	- Necessity of extensive areas. - Necessity of work with stabilized sludge. - In the project design is essential to consider climatic variables, requiring some knowledge of climatology. - Require intensive labor to remove the dried sludge.

Although this system has several disadvantages, due to the low initial and operational costs, it is a dewatering WTP sludge alternative which is widely used. Examples of use of drying beds have been reported on the work developed in the United States by Murray and Dillon [6]. In this research were visited 469 dewatering WTP sludge systems, in which 47 of the total were drying beds, realizing a conclusion that 10% of the total systems visited use drying beds as sludge dewatering method.

2.2 Bags

In this technology the sludge is stored in large units which are shaped as a big bag. It is made of geotextile woven of high strength polypropylene, which performs two functions simultaneously: containment of solids mass and drainage of liquids present in the sludge. This drainage occurs through small pores, allowing the volume reduction of the contained waste and, obviously, decreasing the percentage of liquids present in the sludge. While the volume reduction is happening in a determined unit, this unit can be filled by repeated fillings until the available bag capacity is almost entirely occupied by the solid fraction from the waste.

Thus, after the consolidation of the material contained inside the bag, this is opened to properly dispose the sludge or reuse it in manufacturing processes of other products.

Figure 2 illustrates two cases of application of this system for dewatering WTP sludge in Brazil.

Figure 2: a) Curitibanos WTP – Santa Catarina State, and b) Santo Antônio do Jardim WTP – São Paulo State [7].

2.3 Drainage Beds (DB)

This system consists in a natural system of dewatering WTP sludge in which principles of operation and functioning are based on fundamentals of drainage and evaporation.

It is possible to affirm that just as the drying bed, the drainage bed has two operating steps that can occur simultaneously or not. One is the drainage of free water, and another the evaporation. The drain depends on factors related to the physical filtration (basically geotextile blanked used), but when chemicals are used obviously also depends on chemical factors, such as type, concentration and amount of polymer added to aid in the flocculation, what may result in a more effective dewatering. About the evaporation step, it depends on factors related to climate that may or may not be favorable to accelerate the water removal at this step.

The breakthrough considered in the drainage bed in comparison with the traditional drying bed is its highly initial drainage capacity – drainage of free water present in the WTP sludge – since the WTP sludge is extremely fluid. Cordeiro [8] [1] due to the fact of identify the necessity of initial drainage of free water, developed the drainage bed, which in its final design has only two filter layers, the geotextile blanket and gravel, with the blanket being the most important layer in the initial drainage of free water from the sludge. The geotextile blanket used in the DB has superficial density of 600 g/m² and is a nonwoven type.

In Brazil there are some WTPs that deployed the DB system and have succeeded in its operation. Some examples are the following WTPs: Cardoso (São Paulo State), Guanhães (Minas Gerais State) and Guaíra (São Paulo State). Figure 3 shows some pictures of Guaíra WTP.

Figure 3: DB Guaíra WTP: DB empty, DB filled with WTP sludge, WTP sludge dewatered, zoom in WTP sludge dewatered [7].

3 APPLICATIONS FOR WTP SLUDGE

As discussed in the previous item and in the introduction, the first step when it is thought about treating WTP sludge consists in dewater it, reducing its volume. However, performing only this step does not mean a sustainable treatment of this type of waste, but to make this treatment truly sustainable, it is necessary to give a proper allocation or application for this waste.

There are many potential uses for WTP sludge. Among these are available uses in the soil, cement manufacturing, bricks or ceramic manufacturing, commercial cultivation of grass, compost, commercial soil, citrus plantation, settling in water with low turbidity, coagulant recovery, H_2S control, discharge in collection network sewage, disposal in landfill, energy generation, etc. [9].

There are already real applications of all of these cited potential uses in Brazil and around the world. Nowadays, with the need to think of waste as an opportunity and not as a problem, the search for new potential uses of waste has intensified, including opportunities for the sludge.

In Brazil, the major application for dewatered WTP sludge has been to manufacture brick and ceramic, concrete matrix and in paving sidewalks for pedestrians.

Table 2 presents briefly some experiences of WTP sludge applications.

4 MATERIAL AND METHODS

Thinking about improvement of the DB dewatering method, it was developed some research conducted by Reis [7], in which it was made some essays in DB prototypes covered and uncovered, aiming better efficiency in the evaporation step, based on the premise that this dewatering technology would get better efficiency in tropical countries, like Brazil for example.

To conduct this research, DB prototypes comprised of a nonwoven geotextile blanket with superficial density of 600 g/m², samples of raw sludge from WTP and plastic covering were tested. Six comparative assays in DB prototypes with and without covering were performed at the same time for the evaluation of the drying phase by evaporation. Changing in sludge humidity was monitored by measuring the total solids.

Different heights of the plastic covering (varying from 0.2 to 0.6 m) were applied in the DB prototypes. For each assay, samples of sludge in prototypes were daily collected for dewatering monitoring in the phases of draining and drying (total solid content).

5 RESULTS AND DISCUSSION

Comparative results in DB acquired during seven days in the assay number 1 are showed in Figure 4.

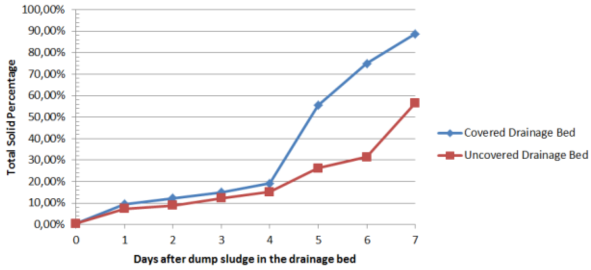

Figure 4: Total solid content in DB with and without covering (regard to the assay with height of plastic covering equal to 0.2 m in relation to the prototype border).

According to the graph (Figure 4), for the solid content in all DB assays, with and without covering, the most significant results were the assays number 1 and 6, which used the plastic covering with 0.2 m height, resulting in an increase of 30% in the total solid content. From Figure 4, it is clearly perceptible that the days in which occur simultaneously the drainage and evaporation steps are from the dump initial time until the fourth day. On the other hand, from the fifth day to the end occurs only the evaporation step, evidencing the best efficiency when the covering is used.

Figure 5 shows a comparison between the conditions of sludge on the seventh day from the assay number 1, which allows to visually realize the superiority of water removal from sludge and consequent reduction of volume in the covered drainage bed in relation to the uncovered one.

Figure 5: Conditions on the seventh day of sludge in the essay number 1 in the covered DB (left side) and in the uncovered DB (right side).

For the other assays with 0.3 m, 0.4 m, 0.5 m and 0.6 m height of the covering, the total solid content was lower, although it was always higher in covered DB.

6 CONCLUSIONS

The use of plastic covering in DB increases the ability of natural thermal drying (solar energy) and the same result may be expected from the use of this system in other tropical countries.

Furthermore, this research suggests possibilities for novel investigative studies with covered DB, with different coagulants uses, influence of initial total solid content in raw sludge, height of raw sludge applied in the DB, influence of climate variables, use of chemicals, applications to the sludge according to its amount of solids, etc.

Above all, it is important to note that, a promising theme to be investigated consists in alternatives/opportunities for the reuse of processed sludge. Thus, it is essential that technologies for sludge treatment does not only attempt to the dewatering of sludge, but also are linked to forms of reuse the waste dewatered, such as in power generation.

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Table 2: Experiences of WTP sludge applications – case studies.

Author, application	WTP coagulant	Notes/considerations
Souza [10], application in concrete as aggregate	$Al_2(SO_4)_3$	In research aiming the waste reuse, he produced a composite of WTP sludge and sawdust to use as aggregate in concrete. The concrete containing the composite was prepared with the full replacement of conventional aggregates, characterized as non-structural lightweight concrete with thermal properties that suggest application in lightweight elements for sealing and thermal insulation.
Tartari [11], application in red ceramic manufacturing	Poly-aluminum chloride (PAC)	It was studied the incorporation of WTP sludge in red ceramic manufacturing and the results showed that the sludge presents characteristics of silty clays of low plasticity, being possible to replace similar clays up to 8%, according to the physicochemical properties specified in manufacturing standards for red ceramic cladding (brick).
Hoppen [12], application in concrete matrix	$Al_2(SO_4)_3$	The sludge was used in percentage substitution of the sand dry weight in cement matrices and the results showed that for substitution on 4 and 8% the concrete strength values were higher than 27MPa at 28 days, allowing multiple applications for this concrete, once they are non-structural application, since it cannot be certain predicted the behavior at long time. The viable applications are subfloors, sidewalks and residential floors, concrete covers for pit and pull boxes roofing, etc.
Costa [13], application in sidewalks	Aluminum polychloride (APC)	It was simulated the manufacturing of the concrete daily performed by the masons with the traces 1:2:3 (cement:sand:gravel) in mass and with visual monitoring of its workability. The viability analysis of the use of sludge as aggregate was based on axial compression tests and diametrical compression tests. These tests demonstrate that for traces using 5, 10 and 20% of sludge, it was obtained axial compression resistance higher than 15MPa, being considered as very good results, since for sidewalks are recommended values of 10MPa. About tensile tests there were no references, but even though it was possible to realize that the use of sludge as a compost with sand as fine aggregate interfere in the results, being recommended the use of percentages close to 10%.

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