

Wastewater Sludge Used as Material for Bricks Fabrication

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Abstract. Current world trends related to wastewater sludges are: reuse in agriculture, utilization as retaining material for petroleum products or utilization in construction. Bricks from sand-cement or autoclaved cellular concrete are commonly used in construction. The authors propose innovative receipts for bricks and plasters based on textile wastewaters sludge. Centrifuged sludge is mixed with cement to obtain bricks and plaster. For bricks, the mixture is represented by 45% cement and 55% sludge. The paper presents the obtained results and the new materials used for bricks fabrication.

1. Introduction

Wastewater sludge is considered as a waste and it is generated by the wastewater treatment plants (WWTPs), when the water/wastewater and suspended solids are separated. The treated water is discharged to aqueous environment or reutilized while the sludge is removed for further treatment and final disposal [1]. Considering the large number of WWTPs the amount of the generated sludge is also significant. The specialists around the world, are continuously seeking for cost-effective solutions for a future utilization of the generated sludge.

A wide variety of sludge treatment technologies is used by specialists around the globe. The treatment technologies depend on both the quality and quantity of the generated sludge. Regarding sludge stabilization, anaerobic and aerobic digestion are the most common used methods in European Union (EU) [2]. Anaerobic digestion is most commonly used in Italy, Spain, Slovakia, UK, Spain and Finland [2]. Aerobic digestion is the preferred in countries like Czech Republic or Poland [2].

Chemical stabilization, conditioning with lime or other chemicals are generally of minor importance, although they are used mainly in some EU countries. However, in most EU countries (including Romania) the sludge disposal is still an important method used for sludge management.

Industrial wastewaters are treated through various processes. The industrial wastewater sludge resulting from the treatment process has a variable physico-chemical composition, depending on the composition of treated wastewater and the nature of the chemicals used for the treatment [3]. This resulting sludge is considered a waste, according to the EU environmental legislation. The sludge must be classified according to the physicochemical characteristics and according to the environmental legislation in force (In Romania: Law 211/2011, Regulation 1272/2008, HG 856/2002) in classes of hazardous, non-hazardous or inert waste. According to this classification, the waste is transported, inerted and stored in specialized warehouses on waste classes. Transport costs, inertization and storage involve high costs, which have a final effect on total wastewater treatment costs.



2. New receipt for bricks realization from wastewater sludge

The wastewater sludge utilization for bricks realization is known and few experiments are available in the literature [4]. The authors proposed another innovative technology/receipt, to be implemented at the industrial application level, that is based on the patent no. RO 125384/30.06.2014 entitled "Procedure for obtaining brick and plaster construction materials".

Starting from the necessity of valorization of the sludge resulted from an industrial WWTP, its aim is to transform the sludge into an inert waste (by inclusion in a matrix that does not allow the leaching of chemical elements), which may have various utilities (in the present case the use as building material was pursued: bricks, plasters). Up to now, fired clay bricks or sand with cement autoclaved aerated concrete are used in construction.

The new receipt for bricks realizations is based on a mixture between sludge and cement. The sludge inertia process requires a humidity of less than 80%. For this purpose, it is centrifuged to reduce the humidity from (90-95)% to a maximum of 80%. The preparation of the sludge sample, starting from the characteristics of the treated wastewater to the dehydration process, has two purposes: the relevance and success of the experiment i.e. access to a positive result in terms of the initial objective. Each stage of the process will be influenced by the previous ones, the links between the initial conditions and the results are affected by a complexity of factors. According to the mentioned patent, the main stages of the sludge recovery and inertization process are:

- a) obtaining sludge by treating wastewater;
- b) sludge dewatering by filtering through bag filters and/or centrifugation;
- c) exploitation of sludge by inerting it with cement.

3. Methods and methodology

The authors performed a series of experimental determinations for bricks realization. Was considered a WWTP from an industrial and technological park, where seven textile companies have the headquarters. The experiments were realized in March 2017, when the wastewater characteristics were monitored. The quality indicators for the generated wastewater are presented in Table 1.

Table 1. Physical and chemical characteristics of wastewater from which raw sludge for experiments is obtained.

Parameter	Units	Values
		Period 01.03.2017 - 08.03.2017
pH	unit. pH	8.74 - 8.92
Suspended solids	mg/l	511.0 - 624.0
Biochemical Oxygen Demand BOD	mg O ₂ /l	342.19 - 367.42
Chemical Oxygen Demand COD	mg O ₂ /l	674.28 - 686.06
Detergents	mg/l	3.04 - 3.26
Total Phosphorus	mg/l	2.64 - 2.88
Sulfates	mg/l	378.24 - 394.62

The evaluated sludge was used for the bricks realization. Samples of sludge were collected and used in the experiments. Sampling involves sampling at different points of the investigated batch. According to the working procedures, for a maximum of 2 tons of sludge, 10 samples of 200 grams were taken, forming a homogeneous sample of 2 kg. Ten such samples of 2 kg were taken. These were then homogenized and constituted the sample to serve for the experiments to be carried out.

Samples were taken in 2.000 ml plastic or borosilicate containers, washed and kept in 5% (v / v) nitric acid solution for 24 hours and rinsed 2-3 times with distilled water to which is added acid for preservation); then it is tightly closed.

Transport and conservation of the sludge probe is made at a temperature of (2-5)°C and in safe conditions to avoid damaging or destroying the container and contaminating or losing the sample. The constituted sludge sample is coded and sampled in 3 sub-samples for the experimental tests to be performed.



Figure 1. Preserved sludge sample for physicochemical analysis - sample code N8.



Figure 2. Raw sludge used in experiment 2.10.

4. Experimental results

The wastewater sample is treated with aluminum sulphate, 0,5 g/l, for the precipitation and coagulation of organic and inorganic substances. The resulting sludge after 24 hours of settling is filtered through sludge bags and centrifuged on a laboratory centrifuge. The dehydrated sludge is mixed with cement (45% cement + 55% sludge). The mixture is homogenized for 15 minutes until a homogeneous paste is obtained which is poured into metal or wood mold. Allow to dry for 24 hours, remove from the mold, leaving in the open air for 3-4 days to bring in contact with the slurry from the sludge with CO₂ in the air, which helps to increase the brick's resistance (Figure 3).



Figure 3. Final Brick Product - sample code 2.10.

In Figure 2 is represented the brick sample code 2.10. The physical behavior (for the first three days) of the obtained brick is presented in Table 2. During the experiments several receipts were tested, and the results are presented in Table 3.

Table 2. Physical behaviour in time of the brick sample 10.

Time	12 h	Day 1	Day 2	Day 3
Appearance	Wet, it keeps its shape	The strengthening process is starting	The strengthening process is finalized	The product is dry and hard at mechanical stress (hammering)

Table 3. Results of the experimental tests.

Text/ Experiment	Code	Sludge humidity (%)		Composition (%)		Product Code	Drying time (days)	Final product characterization
		Before dehydrating	After dehydrating	Cement	Sludge			
Test 2/ experiment 2.10	N8	97.06	65.28	45	55	Brick 2.10	3	The product is dry and hard at mechanical stress (hammering)
Test 2/ experiment 2.11	N8	97.06	65.28	40	60	Brick 2.11	3	The product is dry but porous and brittle at mechanical stress (hammering)
Test 2/ experiment 2.12	N8	97.06	65.28	50	50	Brick 2.12	3	The product is dry, very hard, resistant to mechanical shocks
Test 3/ experiment 3.4	N10	91.51	63.55	45	55	Brick 3.4	3	The product is dry and hard at mechanical stress (hammering)
Test 3/ experiment 3.4	N10	91.51	63.55	40	60	Brick 3.5	3	The product is dry but porous and brittle at mechanical stress (hammering)
Test 3/ experiment 3.6	N10	91.51	63.55	50	50	Brick 3.6	3	The product is dry, very hard, resistant to mechanical shocks
Test 3/ experiment 3.10	N12	96.22	79.01	45	55	Brick 3.10	3	The product is dry and hard at mechanical stress (hammering)
Test 3/ experiment 3.11	N12	96.22	79.01	40	60	Brick 3.11	3	The product is dry but porous and brittle at mechanical stress (hammering)
Test 3/ experiment 3.12	N12	96.22	79.01	50	50	Brick 3.12	3	The product is dry, very hard, resistant to mechanical shocks

5. Conclusions

For the final brick products, the best results in terms of mechanical resistance and stability over time are obtained for experiments 2.10, 2.12, 3.4, 3.6, 3.10 and 3.12. These experimental products will be physico-chemical analysed, in order to be established the compliance with the environmental legislation (in Romania: Law 211/2011, HG 856/2002, OUG 95/2005) regarding waste and establishment of the waste character (inert, non-hazardous, dangerous).

From Table 3 results that the increase or decrease of the ratio between sludge and cement compared to that provided in the patent no. RO 125384/30.06.2014, adversely affects the stability of the final product.

6. References

- [1] Fytili D and Zabaniotou A 2008 *Ren. and Sustain. En. Rev.* **12**(1) 116-40
- [2] Samolada M C and Zabaniotou A A 2014 *Waste manag.* **34**(2) 411-20
- [3] Yang G, Zhang G and Wang H 2015 *Water Res.* **78** 60-73
- [4] Anjum T, Khan H I U H and Shauket I 2017 *Earth Science Malaysia* **1**(2) 10-12

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