THE DEVELOPMENT OF PELLETIZATION PROCESS OF THE SLUDGE OBTAINED AS SOLID WASTE ON WATER TREATMENT PLANT – WTP.

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ABSTRACT

Pellets were prepared with Water Treatment Plant - WTP sludge and some pelletization binders as bentonite clay, cement, thermoelectric powder ash and sodium silicate to be used in adsorption processes on different flow rates 60 mL min^{-1}, 30 mL min^{-1}, 15 mL min^{-1} and 7 mL min^{-1} to remove soluble zinc ions with different initial concentrations. The results indicates the adsorption of 35,8 %; 46,6 %; 47,9 % and 52,7 % of the total zinc ions present in solution for flow rates of 60 mL min^{-1}, 30 mL min^{-1}, 15 mL min^{-1} and 7 mL min^{-1} respectively. The lower flow rate shows the tendency to be higher removal and the pellets with the addition of cement shows better adsorption properties in comparison with other binders. Most of the adsorption processes reach the equilibrium time after 300 or 360 min of continuous percolation.

Key-words: Adsorbent, Treatment, Water, Zinc, Sludge

INTRODUCTION

The water has high capacity to dissolve chemical elements and compounds with the tendency to carry in solution many toxic compounds to the environment. Some solid substances deposited near river basins and the domestic and industrial sewage discharge have the tendency to be carry and deposited in the water flow, resulting on dirty surface waters with the possibility of illnesses transmission. Nowadays, the sewage collection systems and sewers treatment plants have as objective the collection and null discharge of pollutants in surface waters. Many research projects have been developed trying to study the processes of treatment of pollutant discharges to reach the water quality parameters, established by the environmental regulation for direct discharge in surface water bodies.

There are many research projects under development which aims to search a technical and economic alternative, environmental advantageous to use the Water Treatment Plant - WTP sludge. The use of WTP sludge to remove soluble toxic ions from contaminated water represents a possibility to reduce the ambient costs and impacts associates to the final discharge of wastewaters. Nowadays, in Brazilian federal state of Paraná are produced, approximately, 4,000 t/month of WTP dry sludge, more than 50% are produced just in the capital city of Curitiba.

The development of the adsorbent material to remove soluble ions from industrial and domestic discharges represent the possibility of reduction of the concentration of soluble toxic compounds and the control of the water quality of the surface water bodies, some of them under eutrofication process, with the undesirable growth of seaweed which compromises the quality of surface waters, mainly observed at polluted urban streams. The adsorbent material was developed to assist the recovery process and to the maintenance of the water quality of the water resources, mainly those located near big cities with heavy environmental impact.

The project aims the study of the peletization process of solid residue produced as sludge on the sedimentation tank at Water Treatment Plant- WTP. The sludge was dried and after pelletization the spheres were used as adsorbent material to remove soluble zinc ions in similar concentration with those found at water samples collected at urban stream water. The zinc content were measured at water samples collected at Pirajuçara urban stream with dense pollution located in the metropolitan area of Sao Paulo- Brazil. The project is providing information's about the adsorption of soluble zinc ions, the determination of the concentration for saturation of the adsorption columns, the adsorbent mass influence and the effect of the pelletization binder on the adsorption removal percentage, those information's are an indication of the adsorption process as a possibility to water treatment of urban stream with dense pollution.

MATERIALS E MÉTHODS

The Water Treatment Plant –WTP Sludge

The WTP processes are responsible to turn the raw water collected at uncontaminated reservoir or river on potable water using chemical engineering processes. The volume of the produced sludge depends directly of the dosage of the chemical reagents used in the WTP processes, usually on the range of 0,2 % to 5% of the total volume of treated water, the total amount of the solid particles produced is in the range of 1 to 40 g for each liter of treated water, with 75% to 90% of suspended solids and 20% to 35% of volatile compounds.

The increasing demand for quantity and quality of the drinking waters and the low quality of the raw water of the reservoirs and rivers have resulting on the need of increasing amount for chemical additives of water treatment processes to reach the standards of potable water. This effect also increases the Water Treatment Plant – WTP sludge quantities discharge in to the environment.

The chemical process involving those operations is called conventional when includes coagulation, flocculation, decantation and filtration of the water residues, normally the solid residues are composed by colloidal particles of chemical, physical and biological nature. If the raw water needs specific process to reach the potable standards, the treatment became more demanding, onerous and economically impracticable (1). The processes of flocculation, decantation and filtration are also known as clarification process (2) (3), Figure 1.

The flocculation and decantation processes are responsible for the separation of the impurities presents at the river raw water, the flocculation process is used to form flakes which are separate of the treated water for sedimentation in sedimentation tank. The treated water is kept over the solid sediment and it is pumped to cross a series of press filters to remove the remained solid particles from the treated water. The produced sludge is main composed by suspended solids, the chemical compounds applied during the water treatment and also others compounds present on raw water, such as seaweed, bacteria, virus, organic particles in suspension, sand, clay, silt and inorganic compounds as calcium carbonate, magnesium carbonate , iron hydroxide and manganese hydroxide.

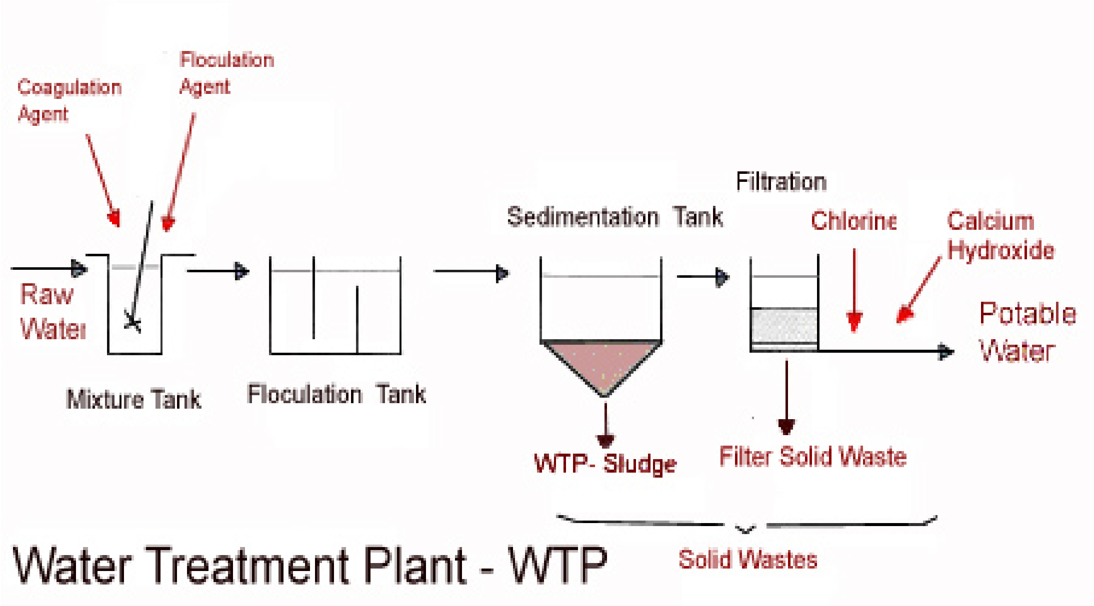

Figure 1: The simplified flow chart of the water treatment plant- WTP[(3)].

<u>Pelletization Process</u>

The sludge samples were received with high content of humidity; therefore they were dried, disaggregated and mixtured with the binders for pelletization. The mixture was used to produce WTP sludge pellets to be applied as adsorbent bed on adsorption columns manufacture[(4)].

The WTP sludge does not show plastic properties for pelletization and to produce the adsorbent pellets to be used to manufacture the adsorbent bed column. The spheres were prepared with four different mass formulations, WTP sludge mass with the addition of bentonite clay, thermoelectrial powder ash, sodium silicate and commercial Portland cement. The addition of those binders increases the plasticity and turns the mixtures adequate to be used on pelletization processes. Initially the spheres of the WTP sludge were prepared from the dry mixture with 90% of the sludge for 10% of the binders (in mass), water was added and the agglomerated fractions were manually separated. The produced spheres were drying to constant weight (about 0,98g to 1,24g for each pellet) and burned in electric oven at 600ºC for 1h.

The number of WTP spheres to be used as adsorbent bed was increasing during the development of the project and it was necessary to contact the Institute of Technological Research of Sao Paulo State - IPT to enhance the production of WTP sludge spheres. The obtained spheres were submitted to a mechanical resistance test for the determination of the compression strength of the green spheres and after thermal shock. The compression strength allows measuring the binder effect on spheres preparation, properties and resistance, after drying and submitted to the thermal shock on different temperatures, during 10 minutes at 300^{o}C, 500^{o}C, 700^{o}C and 900^{o}C.

Adsorption Process

The development of the adsorption processes using adsorbent columns were controlled by the measurement of the zinc ions concentrations in different times of percolation:1 ;2 ;3 ;4 ;4,5 ;5 ;5,5 ;6 ; 7 and 8 hours. The collected aliquots were centrifugued and the zinc concentration was determined in soluble fraction. The complex tritation was used to measured zinc concentrations, for lower zinc concentrations the induced plasma emission spectrometry – ICP was used. The obtained results were used for adsorption calculations [4] [5] [6]

The concentrations of the adsorption processes were kept near the range of the values obtained for soluble zinc measured on water samples collected at the urban stream[7][8][9]. The process temperature and the pH were kept constant in the range from 28 ^{o}C to 30^{o}C and from 5 to 6 respectively during all adsorption processes. Initially the adsorption processes were studied downflow with flow rate of 60, 30, 15 and 7 mL min^{-1}, after some experiments it was changed for upflow adsorption process, performed at flow rate of 7 mL min $^{-1}$[10].

RESULTS E DISCUSSION

The prepared spheres were submitted to the test of mechanical resistance to compression. The results obtained for WTP sludge spheres prepared with different binders can be observed at Table 1.

Table 1: The maximum strength values obtained for compression of WTP sludge spheres prepared with different binders (MPa).

Binders	**Green**	100°C	300°C	500°C	700°C	900°C
Sodium silicate	1,73	3,31	2,90	**fracture**	**fracture**	**fracture**
Bentonite Clay	2,25	2,22	2,22	4,04	13,88	19,18
Powder ashes	2,03	1,99	2,73	**fracture**	12,58	**Fracture**
Cement	2,25	8,02*	-	-	-	-

*The spheres prepared with cement were not burnt – The cementation reaction was used to increase the compression strength.

The spheres prepared using bentonite clay and cement shows the higher compression strength after drying; it was also observed the increasing number of fractures for the spheres prepared with the powder ashes and sodium silicate. The zinc removal percentage values can be observed at Table 2, they indicate better adsorption properties of the spheres prepared with the addition of bentonite clay and cement. The WTP cement pellets were elected to prepare the adsorbent fixed bed on adsorption dowflow and upflow processes.

The zinc removal percentages were measured for downflow adsorption process on different flow rates. The higher zinc removal percentage was observed at lower flow rate, 7 mL min^{-1}. The flow rate and the removal percentages can be observed at Table 3.

Table 2: The soluble zinc removal percentages for WTP sludge pellets prepared with different binders (on 60 mL min^{-1}).

Pelletization binders	Removal Percentage (%)
Bentonite Clay	23,27
Cement	17,37
Powder Ashes	10,00
Sodium Silicate	16,00

Table 3: The soluble zinc removal percentages for WTP cement pellets on different flow rate at downflow adsorption processes.

Flow rate (mL min^{-1})	Removal Percentage (%)
60	35,8
30	46,6
15	47,9
7	52,7

The values of zinc concentrations were used to prepare the Figure 2 with different time intervals for percolation on adsorption downflow processes with different adsorbent mass, WTP cement pellets mass were in the range of 5 to 30 g. The obtained adsorption curves for 5g indicate a negative linear correlation with R^2 = -0,995, it was also observed the increasing sigmoidal characteristic, accordingly with the adsorbent mass increase, reaching the value of Qui^2 = 1,160 and the correspondent R^2 = 0,94 for 30g WTP cement pellets.

The breakthrough curves were obtained performing the upflow adsorption processes with WTP cement pellets at flow rate of 7 mL min^{-1}, the results can be observed at Figure 3. The curves were linearized applying the logarithm in the independent (x) and dependent (y) variables. The Table 4 shows the correspondent linear equation and the breakthrough values for Ct/Co and the correspondent volumes.

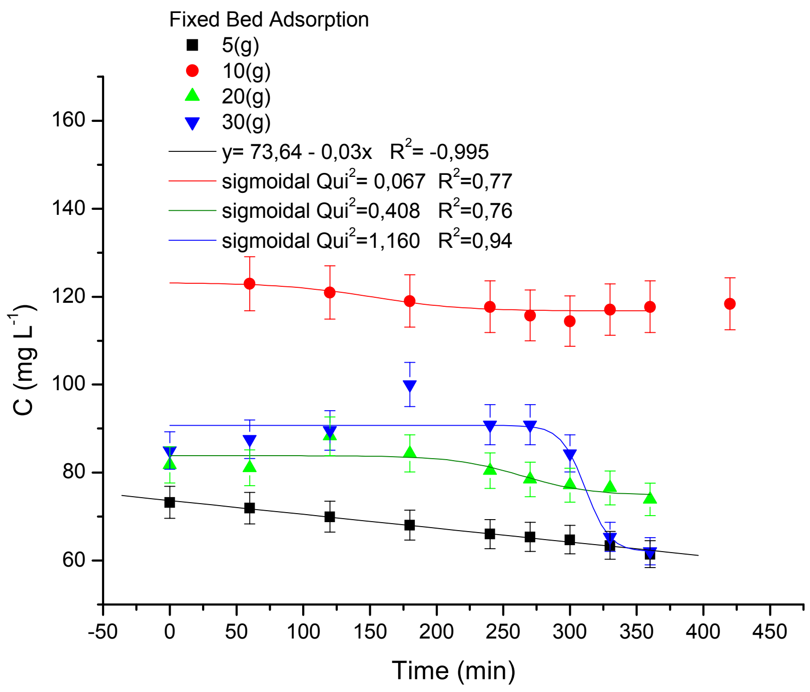

Figure 2: The concentration of the zinc ions on cement- WTP sludge on downflow adsorption process.

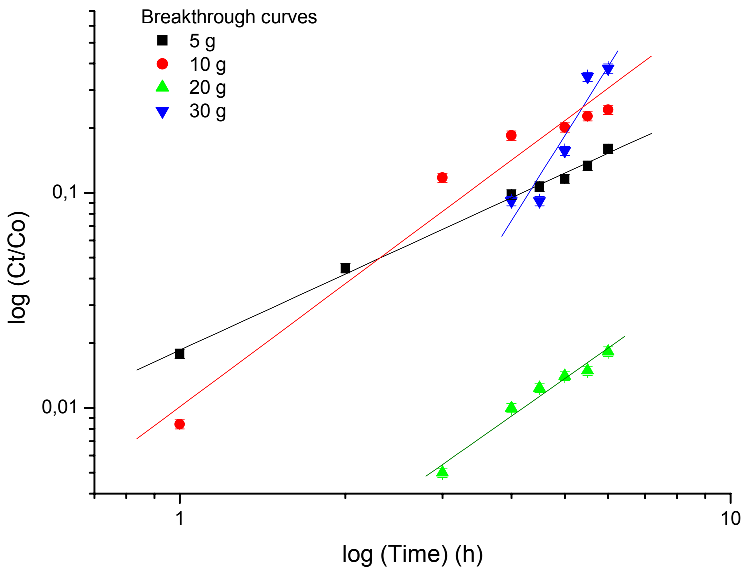

Figure 3: Breakthrough curves for fixed bed adsorption with different adsorbent mass.

The logarithms were used to calculate the linear equations of Ct/Co and time of percolation, Table 4. The breakthrough times, correspondent to the values of Ct/Co = 0,001 were found to be 0,07, 0,28, 1,18 e 1,40 h for 5, 10, 20 e 30g of bed mass respectively. The corresponding volumes of treated urban stream water at breakthrough point were 36 mL, 117,6 mL, 566,4 mL and 672,9 mL respectively. The obtained values is in accordance with some found in the literature for alumina at same flow rate(5)(10)).

Table 4: The breakthrough values (Ct/Co = 0,001) obtained for upflow adsorption processes with WTP cement pellets at 7 ml min^{-1}.

Adsorbent mass(g)	Linear equation	Ct/Co = 0,001 (h)	Volume (mL)
5	Y=-1,74+1,18x R^2=0,998	0,07	36,00
10	Y=-2,01+1,81x R^2=0,923	0,28	117,6
20	Y=-3,13+1,81x R^2=0,984	1,18	566,4
30	Y=-3,59+4,08x R^2=0,998	1,40	672,0

CONCLUSION

The WTP sludge obtained as solid residue can be use as adsorbent material to remove soluble zinc ions from wastewater in similar concentration of those found on analyzed water samples of Pirajuçara urban stream with dense pollution. The WTP sludge was mixtured with different binders for pelletization, the cement and bentonite clay shows the better binder properties to be used on WTP sludge pelletization process. The WTP cement pellets were used to manufacture the fixed bed and the study of the downflow and upflow adsorption process. The downflow adsoption process shows the tendency to be linear for 5 g of adsorbent mass and to be sigmoidal for 30g of adsorbent mass. The breakthrough curves obtained by the upflow adsorption process were prepared with logarithms for linearization. The lower value of breakthrough time was 0,07 h obtained for 5g of adsorbent mass, the higher was 1,40h for 30g of adsorbent mass and the volume of treated water were 36 mL and 672 mL respectively. The obtained values were in correspondence with the literature for non conventional adsorbents.

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REFERÊNCES

1 J.C. Derísio, Introdução ao controle de poluição ambiental, Signus,2ª.Ed São Paulo(2000), 164p.

2 M.P.S. Parsekian, J.S. Cordeiro, Saneamento Ambiental, Maio/Junho 95 (2003), p 50-51.

3 R.N. Shreve, A.J. Brink, Indústrias de Processos Químicos, Guanabara dois 4a. Ed Rio de Janeiro (1977) p.431-451.

4 M. L. Pierce, C. B. Moore Env. Scie. Tech. 14 (1980), 214-216.

5 T. Aoki, M. Munemori Water Research 16 (1982) 793-796

6 C. Namasivam, K. Ranganethan, Environmental Pollution, 82 (1993) 255-261

7 C.Namasivayam, K.Thamaraiselvi, R.T.Yamuna, Pesticide Science 41(1994) p.7.

8 N.Ortiz, M.A.F.Pires, J.C. Bressiani, Waste Management 21,(2001)631-635.

9 B.J.Alloway, D.C.Ayres Chemical principles of environmental pollution, Blackie Academic&Professional,Glasgow, Uk (1993),p 35-50.

10 A.Adak, M. Bandyopadhyay, A. Pal Dyes and Pigments 69(2006) 245-251.