18

DRYING SYSTEM OF SEWAGE SLUDGE - WASTEWATER TREATMENT PLANT IN GDAÑSK

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INTRODUCTION

The 'Wschód' wastewater treatment plant, with average flow of sewage equal to 110 000 m^3/day, is the biggest plant in the voyevodship of Gdañsk. The volume of treated sewage amounts to 60% of the total quantity of sewage in the community of Gdañsk. Until 1993 treatment of sewage was carried out in the facilities that ensured only mechanical removal of contaminants. Poor sanitary conditions of the coastal water of the Gulf of Gdañsk was the main reason for introducing primary chemical precipitation (dephosphatation), using coagulant called PIX. Chemical process of precipitation resulted first of all in effective elimination of phosphates, between 77.6 - 81.8% during the period 1993-95. The removal of organic matter also improved. Due to this the load of total suspended solids in 1995 decreased by 49.1% in comparison to 1992. The removal of organic matter expressed as BOD_5 and COD_{Cr} equaled respactively 34.7% and 32,8%. However, after the introduction of chemical precipitation, the increase of the sludge from 600 m^3 /d (before introducing of chemical precipitation) to 1100 m^3 /d (after introducing of chemical precipitation) was observed. For this reason it was decided to provide support for the coagulation process with anionic polimer. The anionic polimer was introduced in 1995, which resulted in the decrease of the total production of sludge to the amount of 600 - 650 m^3/d.

Modernization of the WWTP also caused the necessity of replacing the formerly used method of dewatering on drying beds (total area of 7.4 ha) by mechanical dewatering in centrifuges of capacity of 8-25 m^3/h and maximum load of sludge of 800 kg DS/h. As a result the operation of the treatment plant became easier, though the problems with utilization of the sludge are not completely solved yet.

https://doi.org/10.15626/Eco-Tech.1997.018

MANAGEMENT OF SLUDGE IN THE WWTP

The average quantity of sewage sludge collected in primary tanks (Dorra type) is 32 500 kg DS/d and the average sludge water content - about 97%. The sludge is transported by gravity force to the tank for the pumping station and next is directed to four open digestion tanks of the volume 20 000 m^3 each. Until July 1993 the sludge was submitted to single-stage digestion followed by dewatering and stabilization on the drying beds during the vegetation season. After the chemical precipitation was introduced mechanical dewatering of sludge in the four cocurrent centrifuges of the capacity 8 -25 m^3/d and maximal load of 800 kg DS/h each was started. The process is supported by polyelectrolite solutions. The supernantant return from the centrifuges is returned to the begining of the plant.

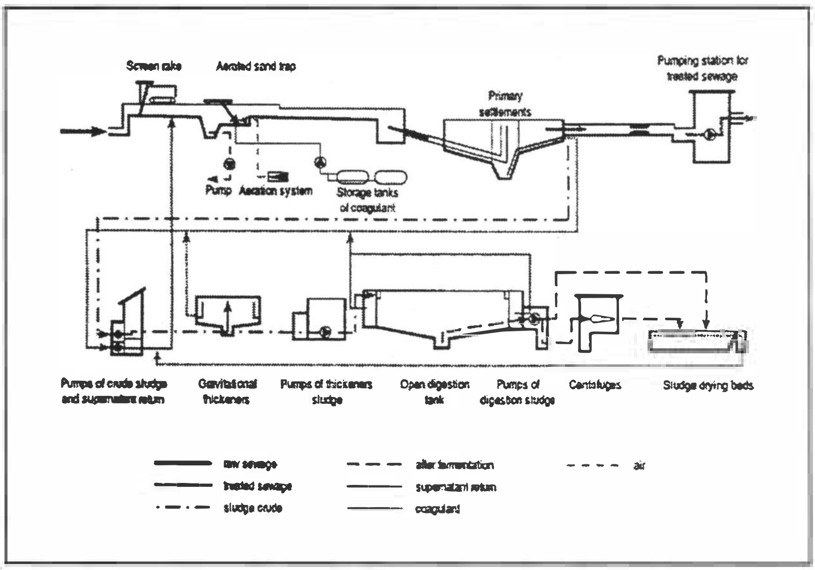

Fig. 1. Schematic of technological processes in the „Wschód" treatment plant in Gdañsk.

THE UP-TILL-NOW EXPERIENCE WITH OPERATION OF CENTRIFUGES

The centrifuge station was put to operation in May, 1993. There are four cocurrent centrifuges, which means that the inflow of the crude and the outflow of the dewatered sludge occur in the same direction. The characteristic parameters of the centrifuges are as follows : the diameter of centrifuge basket equal to 600 mm, the rotation frequency - 1900 [rotations/min], fineness ratio - 4.2 (the quotient of the length of the basket to its diameter).

At the beginning (from March to April 1993) the digested sludges were submitted to the dewatering on the centrifuges. The sludge undergoing dewatering was well digested (the average digestion coefficient was 56%). The introduction of primary chemical pecipitation caused the deterioration of the quality of digested sludge (the average fermentation coefficient was equal 36% between April 1993 and April 1995) [2]. The deterioration of the quality of sludge submitted to dewatering appeared to be the direct reason of the growth of concentration of dissolved organic matter in the effluent (Fig 2a & 2b).

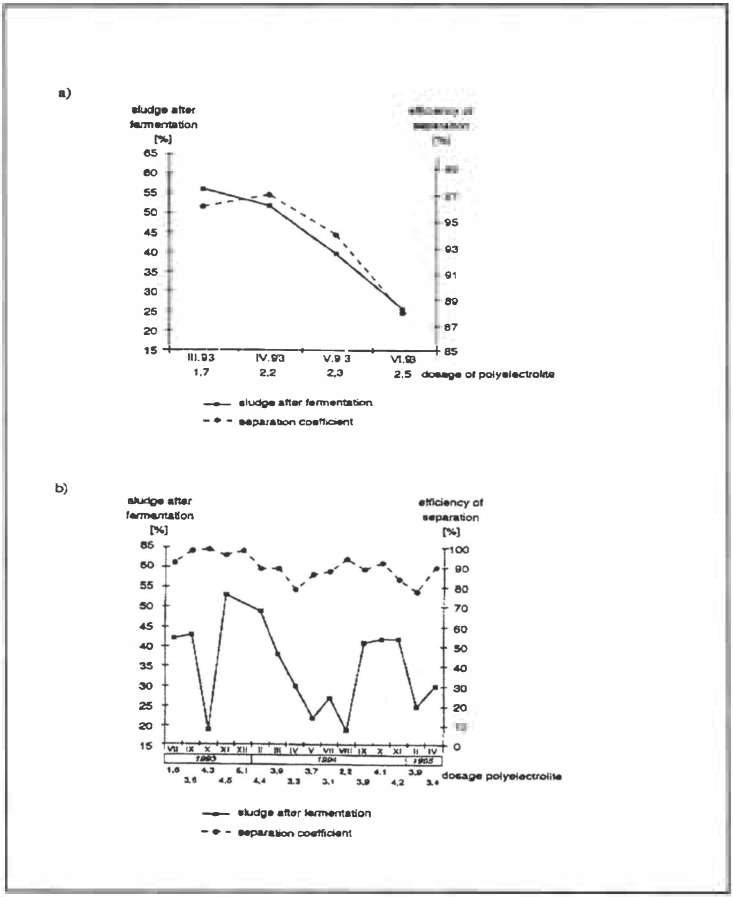

Fig. 2. Separation efficiency of solids from primary sludge, a)without PIX, b) with PIX.

The measurments of dewatering efficiency in the period between March 1993 and April 1995 included the determination of the separation coefficient. The changes of amount of dry matter as a function of various doses of polyelectrolite and various qualities of the sludge given to centrifuges were measured. The quality of sludge was determined by the efficiency of digestion and water content of the sludge. The obtained results are presented in the Fig 2a & 2b. The results showed that for the sludges of digestion coefficient over 50% the separation degree R was higher than 95%, while the doses of polyelectrolite were lower than 3 kg of polimer/ t DS. The separation coefficient for the sludges of digestion coefficient between 25 and 45% was even below 80%. Dewatering of the sludge in the measurment period was between 25 and 30% of DS. It was also found out that in order to ensure the proper operation of the centrifuges the amount of the dry matter in the sludge submitted to dewatering should be at least 3% and the load should be about 10 - 15% lower than the maximal one (equal to 800 kg DS/h) [2].

In order to decrease the doses of coagulant as well as to improve the efficiency of coagulation it was decided to support the process of primary precipitation with the anionic polimer. This allowed to decrease the dose of coagulant to the amount of 125 - 140 mg/dm3 and led to significant improvement of chemical precipitation process efficiency [3,4]. The amount of dry matter in the sludge has increased to 5-6% on average, while previously it was about 2.5 -3%. This fact influences directly the efficiency of mechanical dewatering of sludge - the dose of polyelectrolite in sludge decreased and the total amount of sludge dropped from 100 m^3/d to 70 m^3/d.

THE IMPROVEMENT OF THE SLUDGE CONDITIONING PROCESS

The preparation of the sludge for dewatering (conditioning) includes selection of the suitable type of polyelectrolite and its dose in order to ensure the proper value of separation coefficient as well as effective dewatering and, at the same time, reasonably low concentration of contaminants (which will not disturb the sewage treatment processes) [1]. Since the sludge dewatering station was put to operation in 1993 the measurments have been carried out in order to determine the most effective conditions for sludge dewatering and the optimal dose of polyelectrolite. The analysis of performance of four cationic polyelectrolites A, B, C and D (the letter codes are explained in the Saur Neptun Gdańsk documentation) is given below.The tests were carried out from December 1995 to May 1996. The following estimation criteria were accepted:

- the dry matter of dewatered sludge $\leq$ 25%
- effluent COD in the range 3000÷ 4000 mgO_2 /dm^3
- polyelectrolite dose $\leq$ 3,5 g/kg DS

In order to ensure the homogeneous conditions of the tests the dry matter of the sludge given to the centrifuges was about 3 ÷ 4%, if it was possible.

In Fig. 3 the diagrams showing the averages and standard deviations of the basic parameters determining the usefulness of the polyelectrolites are presented. The parameters taken into account are the doses of polyelectrolite and the estimation criteria given above. The diagrams prove that none of the tested polyelectrolites turned out to be better nor worse than the other ones. Therefore the choice of one of the polyelectrolites depended on non-technological aspects. The average cost of transport as well as availability of service were taken into account. In addition to this the reaction time in the case of one of the electrolites was shorter than for the others. Fig. 4 presents the same diagrams as Fig. 3, but after rejecting the outlayer values with the Q test. In this case the effluent COD for the polyelectrolite D is lower than for the other polyelectrolites.

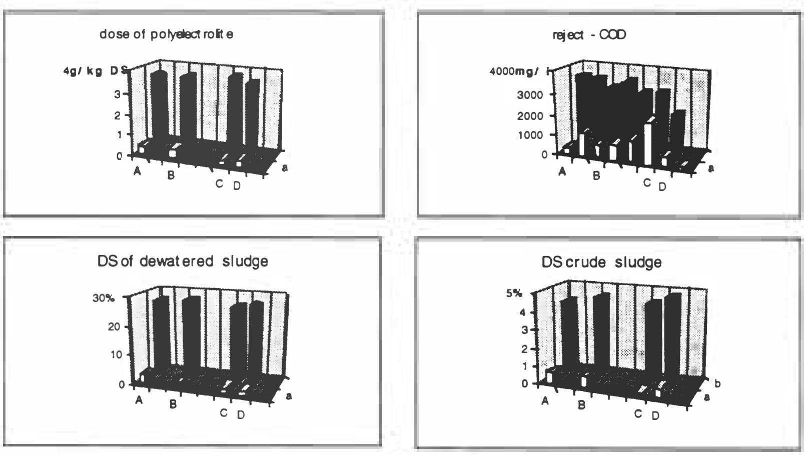

Fig. 3 Averages (a) and standard deviations (b) of all recorded results A,B,C,D - various anion polymers tested

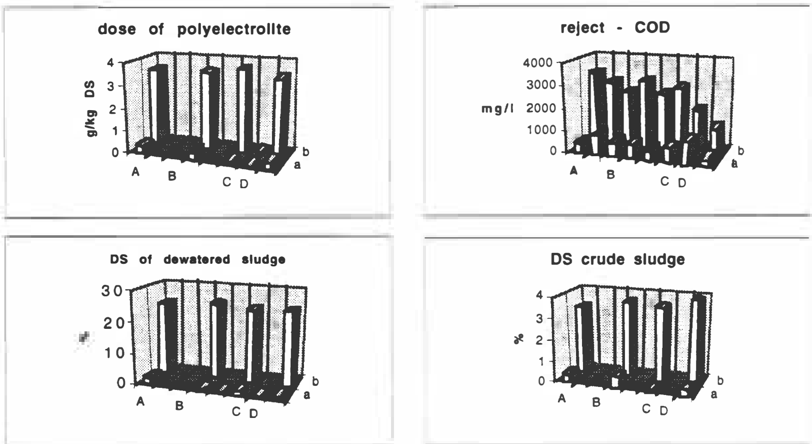

Fig. 4 Averages (a) and standard deviations (b) of results after removing outlayers A,B,C,D - various anion polymers tested

On the basis of the results received after rejecting the outlayers as well as the reaction time and technological and non - technological aspects mentioned above, polyelectrolite D was selected for the sewage sludge conditioning in 1996. Every year the wastewater treatment plant is carrying on the tests in order to optimilize both dewatering and primary chemical precipitation, because the cost of chemicals used in these processes sums up to approximately 25% of the total operation cost of the WWTP.

CONCLUSIONS

1) The amount of the dry matter in the crude sludge should be at least 3% in order to assure the proper operation of centrifuges.
2) Dewatering of the well digested sewage sludge occurs with the separation coefficient higher than 95% while the doses of polyelectrolite are about 3 g/kg DM.
3) The effective dewatering of sludge partly digested requires twice as high doses of polyelectrolite as in the case of the well digested one.
4) Analysis of the influence of four various cationic polyelectrolites on the dewatering efficiency, taking into account effluent COD, the amount of dry matter in the crude sludge and in the thickened sludge, allowed to select one of the polyelectrolites only after the outlayer values were rejected.
5) Investigations should be carried out in order to find quantitative indicators allowing for polyelectrolite performance estimation.

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