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METHODOLOGY AND TECHNIQUES REGARDING THE STABILIZATION OF SEWAGE SLUDGES IN WASTEWATER PLANTS BY MICROWAVE TREATMENT

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ABSTRACT. The paper presents a modern non-conventional technique of stabilization of the sludge coming from the wastewater treatment plant of Sibiu. Sludge samples were progressively treated with microwave radiations and modifications in the sludge composition were monitorized as function of applied energy and time of treatment. An important factor for the devolatilization of sewage sludge is the intimate structure and the age of the sludge. The quality of filtrate regarding the concentration of organic substances is directly proportional with the thermal devolatilization. The obtained results show efficiency of the microwave treatment of sewage sludge according to the energy and exposure time to microwave radiations with optimal parameters at 420 W for 2 minutes.

Keywords: sludge, stabilization, microwave irradiation, wastewater treatment

INTRODUCTION

Sewage sludges resulted from wastewater treatment are complex colloidal systems, with heterogeneous composition, containing colloidal particles (d<1 μ), dispersed particles (d= 1-100 μ), aggregates and suspension materials. Usually they content a high quantity of water and also potentially toxic chemical residues. Disposal practices consist mainly of incineration, land filling and land application (Duvaud et al., 1999). For land application sludge must be treated in accordance with national and international regulations (Spinosa et al., 2001).

Stabilization of the sewage sludge is needed for pathogen reduction and elimination of offensive odors. Technologies of disinfection/stabilization of sewage sludge include physical, chemical and biological methods and are influenced by the tzpe of wastewater treatment (Henze et al., 1997). Among the physical methods, microwave irradiation is a relatively recent application used to reduce pathogenic microorganisms (Alderman, 2004).. Lower frequencies are capable of inducing DNA denaturation and disruption of organic chemical bonds (Martin et al., 2005).

The aim of the present study is to develop a microwave process to stabilize the sewage sludge coming from the wastewater treatment plant in Sibiu and to evaluate the effectiveness of the process.

MATERIALS AND METHODS

Sewage sludge sampling. The 8 sludge samples used in this study were obtained from the Sibiu wastewater treatment plant (Sibiu, Romania). The samples were collected after gravity thickening, (active sludge) in 100 ml volumes and stored at 4oC until further use. An untreated sample (Psample) was used as control.

Microwave treatment. Physical treatment by microwave irradiation of sludge was carried out in a microwave oven for 1, 2 and 3 second and 1 minut at 140, 420 and 700 W.

Determination of suspension materials and volatile organic fraction. The concentrations of suspension materials (Cn) and volatile organic fraction (Cv) were determined by gravimetric assay in accordance with national standard and methods STAS 12586-87, STAS 6953-81. For the determination of the concentration of suspension materials and volatile organic fraction the standard deviation was calculated for 8 samples. The obtained results in conditions of repeatability for the two concentrations are: Cn = 13277.67 mg/l + 119.294 mg/l and Cv = 68.43 % + 0.37 %.

Determination of chemical oxygen demand (COD). COD was determined in accordance with national standards and methods SR ISO 6060/1996.

RESULTS AND DISCUSSIONS

The sludge samples coming from the wastewater plant of Sibiu were progressively irradiated with microwaves and modification of sludge composition was recorded. In this study, two parameters – the reaction time of the microwave process and the energy – were considered. The efficiency of stabilization of the microwave process was evaluated.

Figures 1 and 2 illustrate the main characteristics of the active sludge samples used in the present study: CnBA mean concentration of materials in suspensions, CvBA mean concentration of volatile organic fractions and the age of the sludge expressed in days.

The mean concentrations of volatile organic fractions after the microwave treatment in conditions 1, 2 and 3sec. and 1 minutes at 140W, 420W and 700W are presented in Table 1, figures 3-5.

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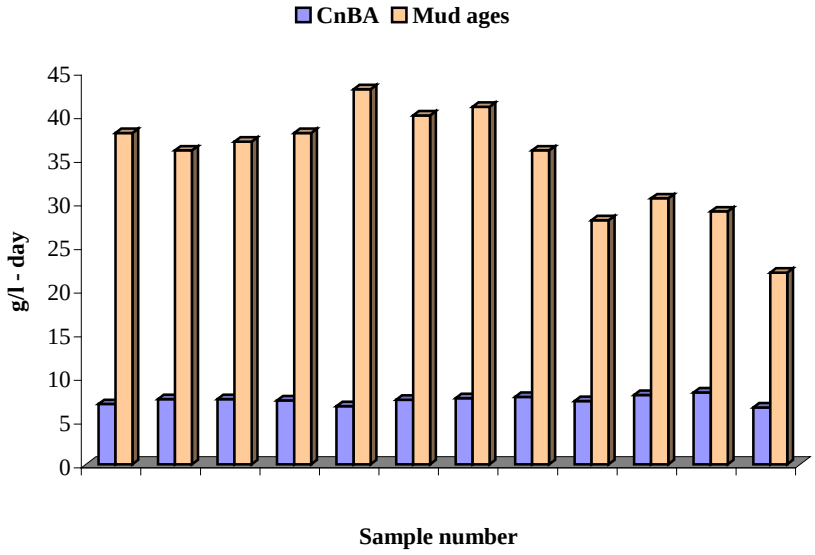

Fig. 1 Concentration of materials in suspensions and age of activated sludge samples before microwave treatment

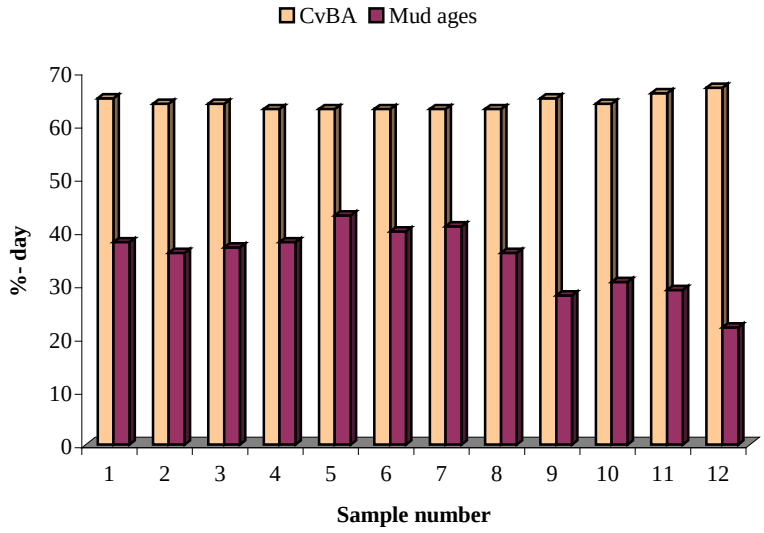

Fig. 2 Concentration of volatile organic fraction and age of activated sludge samples before microwave treatment

Table 1

Mean concentration of volatile organic fractions, $C_{v\,BA}$

Crt.nr.	Samples sludge C_v mg/l	140W 1s C_v mg/l	2s C_v mg/l	3s C_v mg/l	1m C_v mg/l	420W 1s C_v mg/l	2s C_v mg/l	3s C_v mg/l	1m C_v mg/l	700W 1s C_v mg/l	2s C_v mg/l	3s C_v mg/l	1m C_v mg/l
1	11044	11001	10768	10324	8970	10123	9987	8888	5678	8790	8121	7685	4536
2	11134	11032	10789	10344	8999	10111	9989	8989	5467	8567	8089	7654	4439
3	10945	9989	9678	9300	8790	9807	9231	8769	5437	8456	8056	7234	4456
4	11839	10997	10322	10002	9670	9678	9111	8213	5555	9123	8123	6879	4651
5	11937	11321	11112	10978	9567	9980	9123	7890	5123	8456	7210	6845	4234
6	10942	10001	9123	8960	8000	9132	8345	7789	5436	9012	8001	6958	4578
7	11038	10768	10129	9876	9123	10001	8678	6790	5412	9001	8213	6897	4842
8	10947	9678	9213	9000	7980	9145	8567	7790	5234	8997	8004	6669	4435

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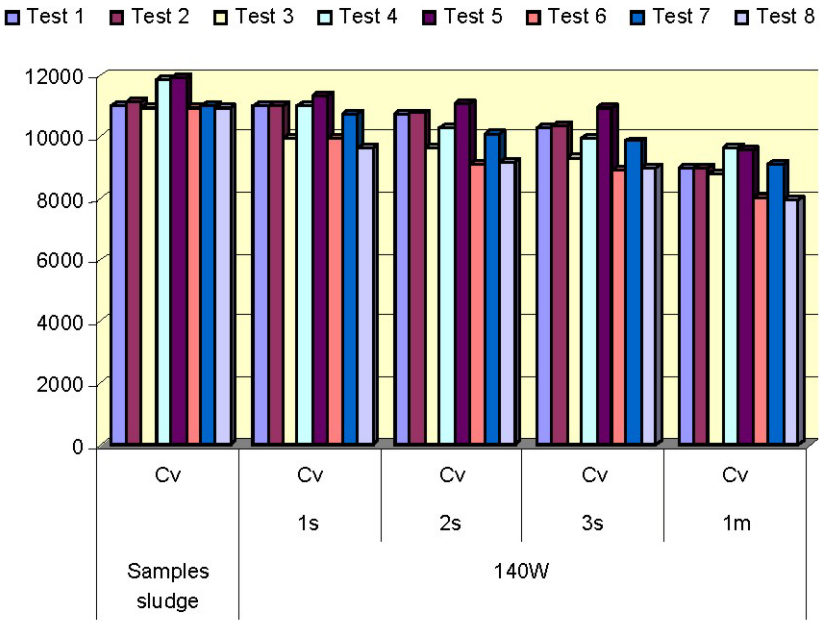

Fig. 3 Mean concentration of volatile organic fractions, $C_{v\,BA}$, for irradiated samples at 140W and in control sample

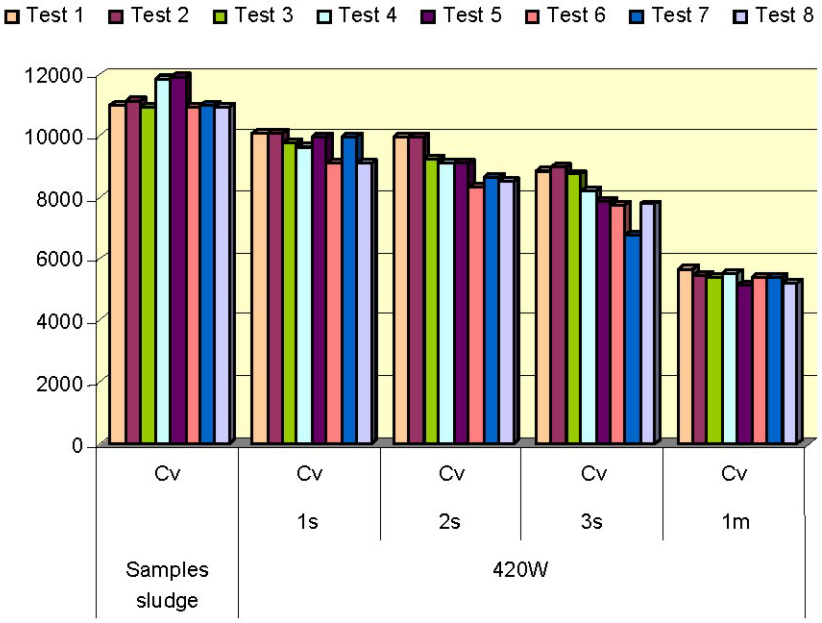

Fig. 4 Mean concentration of volatile organic fractions, $C_{v\,BA}$, for irradiated samples at 420 W and in control sample

Qualitative and quantitative modifications of the chemical composition of sludge were produced: part of the volatile organic fraction was solubilized in filtrates of the samples. To evaluate the devolatilization process at 140 W, 420 W and 700 W at different times of exposure, the parameter chemical oxygen demand (COD) which gives the most oxidizable organic compounds was determined. The filtrate content in oxygen (mg O2/l) of irradiated samples P1 –P8 is presented in table 2.

The results show that the devolatilization process strongly depends rather on the particular characteristics of the sludge samples than on the applied irradiation parameters. The samples initially considered as controls were not identical and presented variable Cn and Cv values and also different ages. For a good evaluation of these parameters the loss of volatile organic compounds were calculated per initial organic content of the control sample. The variation of the loss of volatile organic compounds reported to the initial organic content of control sample, correlated with the age of the sludge and the irradiation parameters are shown in Table 3 and figure 6.

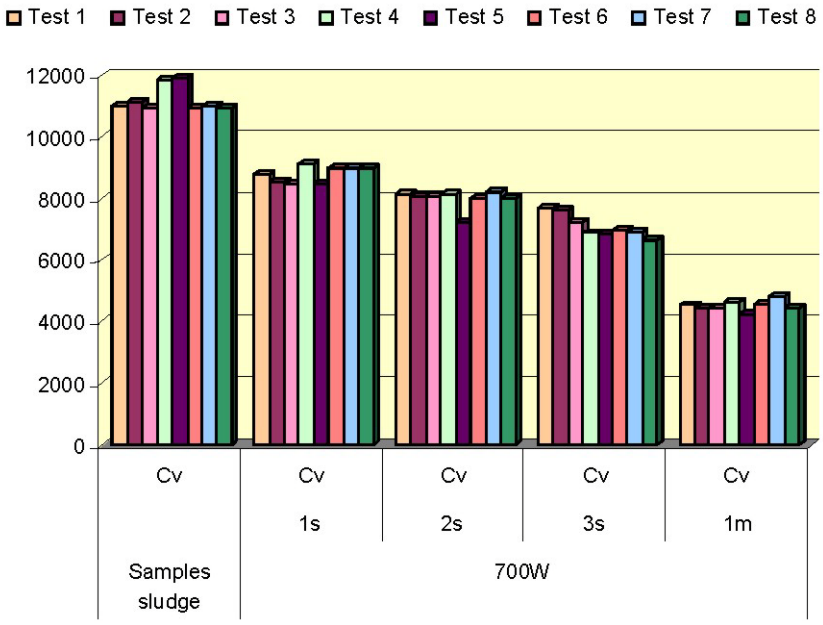

Fig. 5 Mean concentration of volatile organic fractions, $C_{v\,BA}$, for irradiated samples at 700 W and in control sample

Table 2

Chemical oxygen demand (mg O_2/l) of filtrate microwave irradiated

Crt.nr.		140W				420W				700W			
	Sample sludge	1s	2s	3s	1min	1s	2s	3s	1min	1s	2s	3s	1min
1	44	46	56	79	84	60	120	240	345	187	290	330	416
2	34	39	52	75	79	64	123	253	322	189	269	360	428
3	45	50	64	73	90	63	127	249	444	188	294	365	421
4	39	52	65	73	82	62	132	239	434	190	287	367	432
5	37	40	58	69	90	66	133	252	399	192	295	362	412
6	42	44	68	72	94	67	143	256	387	186	239	381	434
7	38	40	66	71	90	67	123	248	368	199	299	354	426
8	47	52	67	80	92	69	142	281	440	193	294	366	419

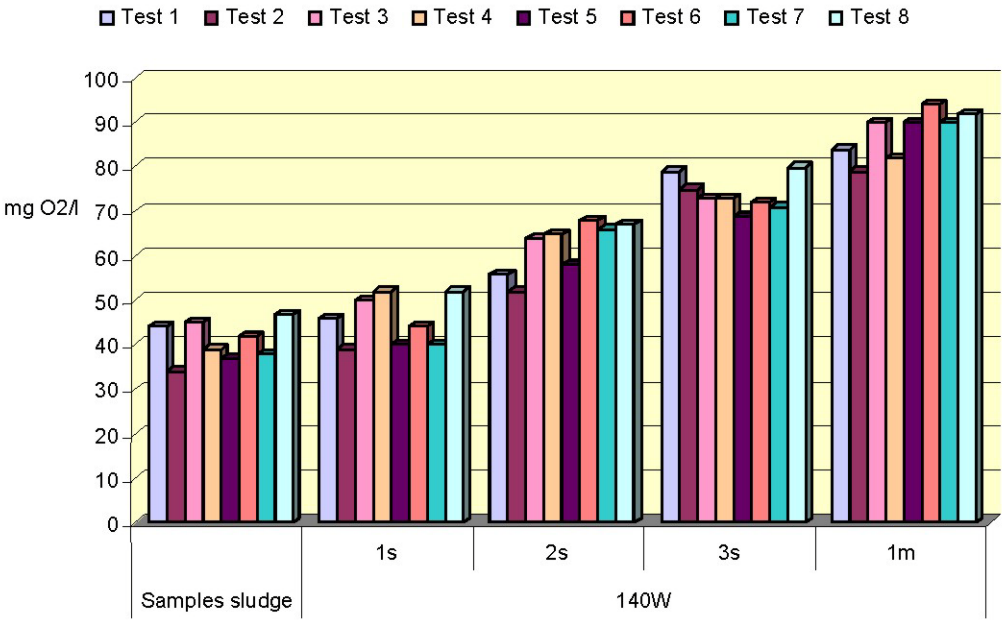

Fig. 6 Chemical oxygen demand (mg O2/l) of filtrate microwave irradiated (140W)

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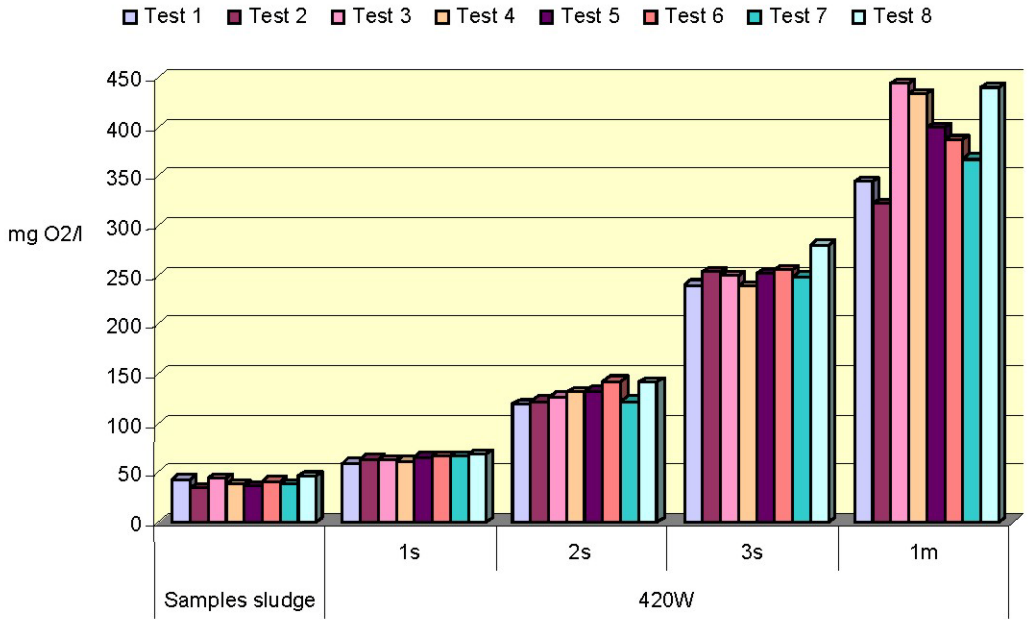

Fig. 7 Chemical oxygen demand (mg O2/l) of filtrate microwave irradiated (420W)

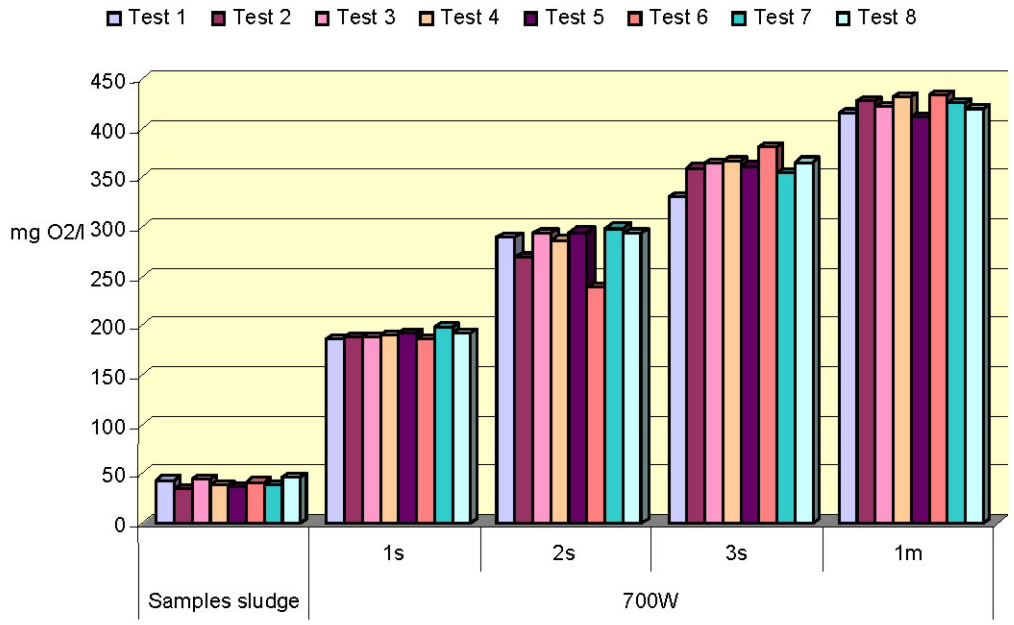

Fig. 8 Chemical oxygen demand (mg O_2/l) of filtrate microwave irradiated (700W)

Degree of devolatilization was 5-10% at 700W microwave irradiation for 1, 2 and 3second and 40-55% for 1 minutes of exposure. The minimum and maximum values most probably are due to the sludge composition and not as a function of sludge age.

Analysis of the degree of devolatilization as a function of applied energy and independent of the age and intimate chemical structure of the sludge samples show that at 420 W and 700 W the obtained results were similar and are generally greater than those for 140W irradiation.

Table 3

The variation of the loss of volatile organic compounds reported to the age of the sludge and the irradiation parameters

Nr.crt.	age	Samples sludge C_v Mg/l	140W 1s C_v Mg/l	2s C_v mg/l	3s C_v mg/l	1m C_v mg/l	420W 1s C_v mg/l	2s C_v mg/l	3s C_v mg/l	1m C_v mg/l	700W 1s C_v mg/l	2s C_v mg/l	3s C_v mg/l	1m C_v mg/l
1	34	11044	11001	10768	10324	8970	10123	9987	8888	5678	8790	8121	7685	4536
2	35	11134	11032	10789	10344	8999	10111	9989	8989	5467	8567	8089	7654	4439
3	36	10945	9989	9678	9300	8790	9807	9231	8769	5437	8456	8056	7234	4456
4	37	11839	10997	10322	10002	9670	9678	9111	8213	5555	9123	8123	6879	4651
5	38	11937	11321	11112	10978	9567	9980	9123	7890	5123	8456	7210	6845	4234
6	39	10942	10001	9123	8960	8000	9132	8345	7789	5436	9012	8001	6958	4578
7	40	11038	10768	10129	9876	9123	10001	8678	6790	5412	9001	8213	6897	4842
8	41	10947	9678	9213	9000	7980	9145	8567	7790	5234	8997	8004	6669	4435

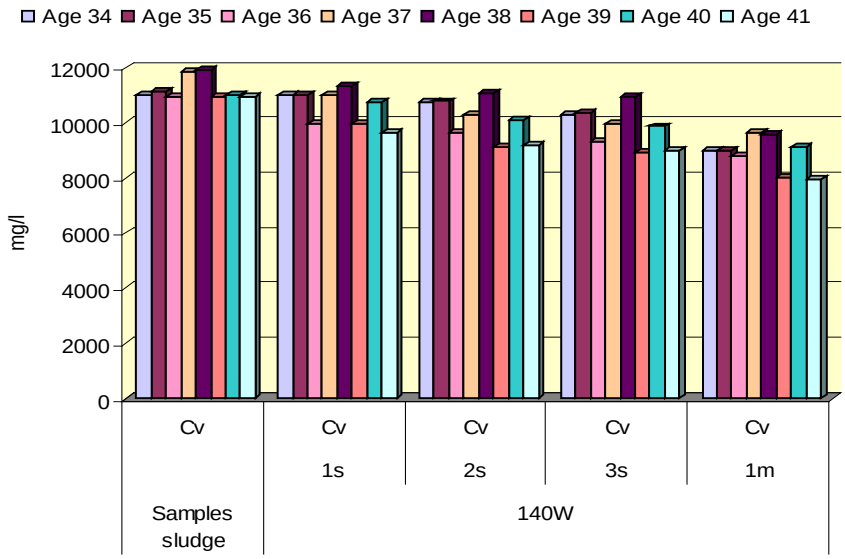

Fig. 9. The variation of the loss of volatile organic compounds reported to the time of the sludge and the irradiation parameters (140W)

CONCLUSIONS

The intimate structure of the sewage sludge represents a key factor in sludge stabilization and is influenced by the composition of waste waters. The age of the sludge is important for the wastewater treatments and for the sludge stabilization.

The volatile organic compounds concentration in filtrate is directly influenced by thermal devolatilization. Microwave stabilization of sludge -as a new application in sludge treatments- was used in the present study. At the reaction time of microwave treatment of 1 minute, the obtained effects were similar for the two energies used in the experiments, 700 and 420 W. For this type of sludge the optimal time of exposure correlated with the economic effieciency of devolatilization is 2 minutes at 420 W.

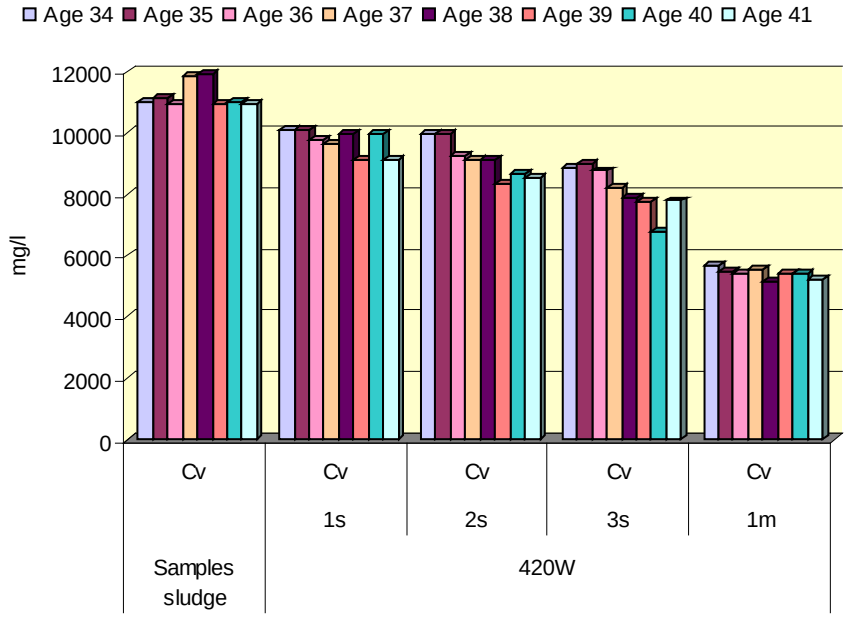

Fig. 10. The variation of the loss of volatile organic compounds reported to the time of the sludge and the irradiation parameters (420W)

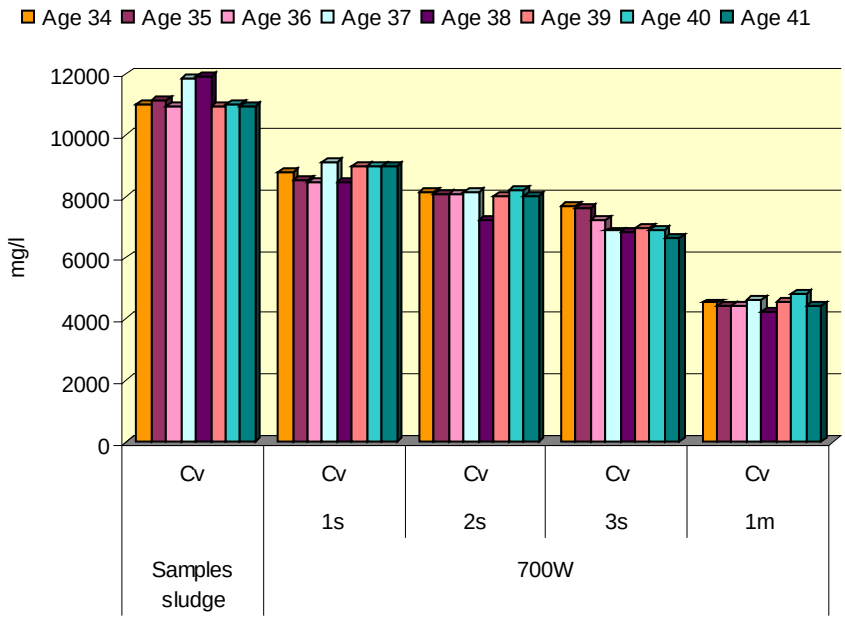

Fig. 11. The variation of the loss of volatile organic compounds reported to the time of the sludge and the irradiation parameters (700W)

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