EVALUATION OF LANDFILL LEACHATE TREATMENT AND TOXICITY

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Abstract

Combined treatment of landfill leachate and municipal wastewater were performed in order to investigate the toxicity of leachate changes during biological treatment. Treatment was performed with A2O activated sludge systems and the share of leachate in the influent was calculated at the base of "worst-case" scenario. Landfill leachate increased initial toxicity of wastewater. During biological treatment significant decline of toxicity was observed. Toxicity identification procedure allowed to conclude, that toxicity of samples was connected with pollutants unionized form, easily stripped or oxidized during the aeration.

Introduction

Landfilling is a widely accepted and used method for the ultimate disposal of solid waste material, due to its economic advantages [1]. Many studies have shown that landfill leachate consisted of different groups of pollutants such as alkenes, aromatic hydrocarbons, acids, esters, alcohols, hydroxybenzene, amides etc. [2, 3, 4]. The most common practice to avoid risk of contamination is to discharge leachate into wastewater treatment plant. High load of macro- and micropollutants may disrupt biochemical processes in biological reactors. More important is that some pollutants may pass biological treatment plant unchanged and contribute to still high toxicity of the effluent. It is well known that toxicity of environmental samples (like wastewater or leachate) is a consequence of numerous contaminants, their synergetic or antagonistic effects and physical-chemical properties. The aim of present study was to investigate the toxicity of landfill leachate both before and after biological treatment. US EPA toxicity evaluation and identification procedure was also used for toxic agents primary identification.

Materials & Methods

Treatment

The experiment was carried out in three activated sludge A2O systems – A, B and C. All systems were operated under the same technical parameters (tab. 1) except for influent characteristic and load. Influent of system A consisted of 15% (v/v) of landfill leachate and 85% (v/v) of water; influent of system B consisted of 15% (v/v) of landfill leachate and 85% (v/v) of municipal wastewater. System C served as a control and was fed with municipal wastewater.

Leachate

Leachate was sampled from municipal solid waste landfill in Zabrze (Poland). Wastewater was collected from wastewater treatment plant in Zabrze-Mikulczyce (Poland). The place for wastewater collection was selected to ensure lack of earlier wastewater contamination by leachate.

Bioassays

Following tests were proposed for leachate toxicity evaluation: *Vibrio fischeri* luminescence inhibition (Microtox) [5], *Daphnia magna* immobilisation test [6], *Thamnocephalus platyurus* acute toxicity test [7].

Table 1 Operational parameters of activated sludge systems A, B and C

Parameter		unit	range	average	median
	A		0.07-0.11	0.08±0.02	0.08
COD load	B	g COD/gTSd	0.07-0.236	0.16±0.07	0.15
	C		0.06-0.175	0.90±0.04	0.06
	A		2.3-3.1	2.6±0.5	2.3
SS	B	g /L	1.6-2.1	1.9±0.2	1.9
	C		1.7-3.7	2.6±0.9	2.8
	A		8.7-10.0	9.5±0.5	9.7
Q	B	L/d	6.2-10.4	9.0±1.9	9.7
	C		8.4-10.0	9.2±0.6	9.6
	A		1.4-1.6	1.5±0.1	1.4
HRT	B	d	1.3-2.2	1.6±0.4	1.5
	C		1.4-1.7	1.5±0.1	1.5

COD- chemical oxygen demand; **SS**- activated sludge suspended solids; **Q**- wastewater flow; **HRT**- hydraulic retention time

Toxicity Identification Evaluation (TIE) procedure Phase I

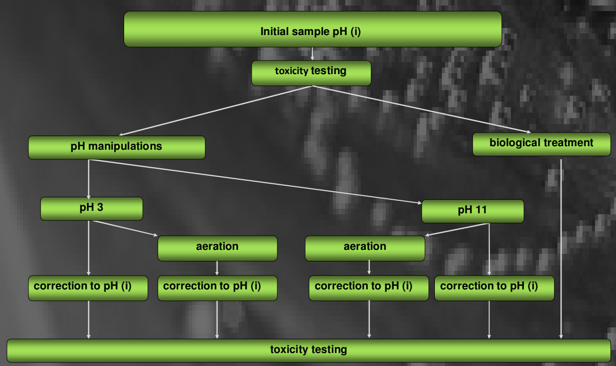

Figure 1. Scheme of toxicity identification and evaluation procedure.

Results & Discussion

Biological treatment of leachate has been shown to be effective in removing organic and nitrogenous matter from immature effluent characterized by high BOD/COD ratio [1, 8]. In present study biodegradability of influents containing 15% of leachate was low: BOD/COD ratio was 0.1 and 0.4 for system A and B respectively. In contrast the BOD/COD ratio of wastewaters (system C) was 0.9. Although removal of organic content reached 71% BOD (48% COD) – for system A and 93% BOD (63% COD) for system B, low biodegradability of influents resulted in high content of organic substances in the effluents (Table 2). The effluents of systems enriched by leachate (A and B) didn't meet the quality standards described for wastewaters introduced to surface waters or ground [9, 10]. In parallel treated wastewater (system C), BOD removal reached 93% (75% COD).

Table 2. Characteristic of raw and treated wastewater

		unit	range	average	median	range	average	median
			influent			effluent		
	A		218-322	288±45	317	83-100	92±8	93
TOC	B	mg/L	317-517	398±77	384	62-167	105±45	95
	C		167-236	193±34	184	19-53	27±13	22
	A		281-537	368±85	334	167-242	192±43	167
COD	B	mg/L	340-695	525±136	440	108-322	197±82	150
	C		211-298	281±58	310	25-127	72±40	65
	A		30-40	35±7	35	10	10±0	10
BOD	B	mg/L	180-200	190±10	190	10-20	13±6	10
	C		240-260	247±12	240	10-20	17±6	20
	A		150-175	163±13	171	2-4	3.4±0.6	3.9
N_{NH4}	B	mg/L	176-236	205±27	195	3-11	5.5±3	7
	C		82-134	103±23	87	0.5-6	2.6±1.7	2.6

The results of toxicity tests were examined for environmental relevance by calculating Toxicity Units (TU) as reported in Table 3. The highest initial toxicity of raw wastewater samples was observed for system B influent. After biological treatment toxicity was declined but still effluent of system B were harmful. In comparison effluents from systems A and C were not toxic except for effluent A, which was harmful to *Vibrio fischeri.* Relatively low toxicity of system A influent was probably connected with low bioavailability of pollutants. System A raw wastewater was characterized by extremely low BOD value. It might be expected that this parameter influenced also initial toxicity of samples.

Table 3. Toxicity of raw and treated wastewater

Organism	Number of tests	System	influent -average TU	effluent -average TU
	5	A	3.6±0.3	0
Daphnia magna	5	B	8.4±0.8	0.6±0.6
	5	C	2.5±0.3	0
	5	A	6.4±0.3	0
Thamnocephalus platyurus	5	B	13.2±0.9	2.9±0.7
	5	C	5.4±0.8	0
	3	A	7.1±0.2	1.8±0.3
Vibrio fischeri	3	B	12±0.2	2.6±0.1
	3	C	6.7±0.2	0

An important increase of toxicity was observed in all tested bioassays when landfill leachate was mixed with municipal wastewater (system B). Toxic units calculated on the basis of toxicity test results for system B were greater than expected on the basis of exposure to influents/effluents of system A and C individually. It might be therefore concluded that mixture compounds revealed synergetic character of impact. The purpose of TIE procedure was to determine which group of pollutants in wastewater sample was responsible for the toxicity. The crucial point of Phase I TIE procedure is the pH variation that affects the toxic properties of complex mixtures by modifying ratio of ionized and unionized species in solution [11]. In present study pH adjustment was always connected with toxicity reduction. The decline of toxicity after different manipulation with comparison to the initial toxicity of samples was reported in Figure 2.

The reached reduction of samples toxicity was comparable to the results obtained after biological treatment. Additionally aeration of samples significantly enhanced this phenomenon. It may be therefore concluded, that toxicity of samples was connected with pollutants in unionized form, easily stripped during the aeration. As the ammonium is extremely pH dependent toxicant, it may be indicated as responsible for overall samples toxicity.

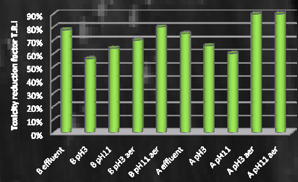

Figure 2. Results of toxicity reduction of wastewaters after different manipulations

Conclusion

Landfill leachate significantly disrupt biological treatment of wastewater. After biological treatment wastewater enriched with leachate did not meet the water quality standards and still was harmful to aquatic organisms. Phase I of toxicity identification procedure allowed to attribute samples toxicity to pollutants in unionized form, easily stripped from the solution during the aeration. The greatest share in overall toxicity of samples might be therefore connected to the ammonium concentration. Although toxicity reduction resulted from pH manipulations and aeration was as high as reduction obtained after biological treatment, it could not be concluded that both processes are similarly efficient. It have to be remembered that for toxicity measurement only acute tests were selected – it is planned to extent the biotest battery to chronic and reproductive tests, which should allow to detect hazard in sublethal concentrations.

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