Biological and physico-chemical treatment possibilities for landfill leachate in Zagreb, Croatia

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Abstract

The leachate from municipal solid waste landfill is highly polluted, so it is categorized as waste water. Its disposal poses an ecologic problem and presents a hygienic risk. The present study presents the experiences of the *in vitro* experiments of the biological and chemical purification of leachate. From the obtained data it is to conclude that satisfactory biological purification can be obtained by addition of the phosphates and zeolite tuff into leachate as well as by means of aeration. The effect of the chemical disinfection process, using raw leachates mixture with the hydrogen peroxide, was illustrated as an improvement of organoleptic properties, the oxidation of organic matter and ammonia as well as a significant decrease of heterotrophic bacteria and coliform bacteria.

Key words: leachate, purification, aeration, zeolite, disinfection, hydrogen peroxide

Introduction

Jakuševec is the main refuse disposal site for the City of Zagreb, with the total current area of about 80 ha. In 1995, the remediation of the Jakuševec Dump Site was initiated and so far 12.5 ha have been turned into a landfill. The leachate from remediated landfill is made up of rain that passes through a landfill site and liquids that are generated by the breakdown of the waste. It is collected by means of the drainage system in two retaining reservoirs. Raw leachate quantity is reduced by recirculation through the depot body and evaporation of the water. Its quality i.e. composition depends on the operational life of the landfill, climatic condition and season, but it is always a mixture of high concentration of organic and inorganic contaminants including ammonia nitrogen, pesticides, heavy metals and microbes. Therefore, leachate is categorized as a wastewater and should be treated efficiently up to the required water quality level prior to draining into the recipient - Sava River. Several concepts for purification of the leachate have been presented, such as constructed wetlands and polishing ponds (Stilinović and Hrenović, 2000), but they have not been applied in situ due to the technical reasons. The options for treatment include recirculating the leachate back to the landfill and then treating for local surface water discharge. Technologies for leachate treatment include biological, physical and chemical methods. In order to meet quality standards for direct discharg of leachate into the recipient there is an intention to integrate biological and physico-chemical treatments (Hrenović et all., 2007; Tofant et all., 2007).

This paper presents the experiences of the in vitro experiments of the leachate purification by the biological autopurification method by (aeration and addition of phosphate and natural clinoptilolite tuff) as well as the chemical oxidation (using the oxidative compound with hydrogen peroxide basis and catalytic action of silver ions).

Material and methods

Leachate

The leachate of Jakuševec landfill was used as a substrate in the experiment. Dark, green-brown, malodorous specimens were sampled on two occasions (rain and sunny weather) from the retaining reservoirs where leachate are collected by means of a drainage system. The leachate was immediately used for experiments.

Natural zeolite tuff

The zeolitized tuff from Donje Jesenje, Croatia contained more than 50% of the clinoptilolite, some quartz and plagioclase and accessory minerals from mica group (illite-celadonite and biotite). Among the exchangeable cations, potassium was dominant in the sample.

Disinfectant

A commercial disinfectant, with hydrogen peroxide-basis and catalytic action of silver ions in traces, was used as disinfectant of leachate. In preliminary experiment, among three final disinfectant concentrations 1500 ppm of hydrogen peroxide has been chosen for the experiment (Tofant et al., 2006).

Experimental design

The experiments for biological treatment were set up in Erlenmeyer flasks containing the 0.2L of leachate during 24h at 25°C. Reactors were aerated with filtered air (1L/min). The phosphate was added in a form of KH_2PO_4 and zeolite tuff in amount 1g/100mL of leachate.

Disinfection as a procedure of chemical treatment of the leachate was performed *in vitro* in high glass container containing 0.5L. Disinfectant efficacies were tested after 1h of contact by determination of bacteriologic, organoleptic and physicochemical parameters aimed for wastewater quality assessment. The efficacy of disinfection was expressed as mean of the $\log_{10}$ reduction factor.

Analytical methods

Determination of chemical parameters for wastewater quality assessment were done in accordance with standard methods using spectrophotometric procedures on DR/2500 and DR/4000 Hach spectrophotometers, Hach conductivity/TDS meter and WTW 330 pH-meter. The samples were filtered before measurements of the chemical parameters through Sartorius nitrocellulose filters, pore diameter 0.2 µm. The numbers of *Escherichia coli* was determined as colony forming units (CFU) on EC X-GLUC agar (35°C/48 h). The CFUs of heterotrophic bacteria was determined on nutrient agar (22°C /72 h), The total coliform bacteria (ENDO agar 37°C/24h) was expressed as logarithm of total CFU *per* one mL ($\log_{10}$ CFU/mL). All measurements were carried out in triplicate and the mean values were presented.

Results

We supposed that the biological autopurification of leachate can be accomplished by applying the suitable conditions for autohtonously present bacteria (Stilinović et all., 2000). By applying only the aeration no significant removal of ammonia from leachate was obtained due to the deficit of phosphate in raw leachate (Table1).

In the second experiment the raw leachate was supplemented with phosphate and natural zeolite tuff before start of aeration. After 24h of aeration phosphate was almost completely eliminated from water. According to the final concentrations of nitrate, nitrite and ammonia it can be concluded that ammonia was successfully removed from wastewater by combined processes of biological nitrification/denitrification, uptake in the bacterial biomass and adsorption onto zeolite tuff.

Table 1. Influence of aeration only (influent and effluent1) and combined aeration, addition of phosphate and zeolite tuff (influent and effluent2) on the purification of raw leachate

Parameter	Influent1	Effleuent1	Influent2	Effluent2
pH	7.58	9.14	7.90	9.04
$P\text{-}PO_4$ (mg/L)	0.30	0.03	88.00	3.00
$N\text{-}NO_3$ (mg/L)	4.9	0.8	22.2	2.8
$N\text{-}NO_2$ (mg/L)	0.014	0.008	0.018	0.013
$N\text{-}NH_3$ (mg/L)	287.5	281.4	377.0	45.0
KPK (mg/L)	693	624	1760	10
Total suspended solids (mg/L)	73	273	169	219
Escherichia coli (CFU/mL)	0.00	0.00	2.00	12.00
Heterotrophic bacteria (10^6 CFU/mL)	5.20	240.00	14.00	250.00
$N\text{-}NH_3$ removal (%)		2.12		88.06

Chemical treatment i.e. disinfection efficacy of the oxidising compound, hydrogen peroxide was assessed (Table 2). The addition of the disinfectant to the raw leachate sample immediately resulted in observable organoleptic changes. The substrate turned light, les turbid and malodour emanations were reduced. This could be ascribed to the oxidation of sulfur compounds as well as malodorous metabolites. The ability of the disinfectant to oxidize organic matter manifested as BOD_5 reduction by about 41 %. However, the mean value still was about 100-fold allowed value for draining to the waters. The oxidation-induced decrease in the concentration of ammonium ions (24 %) may have also reduced ammonia emanation from the leachate. Microbicidal efficacy was expressed as mean $\log_{10}$ RF of sanitation indicator bacteria, heterotrophic and total coliform bacteria. The results obtained were satisfactory, for both indicator bacteria, indicating the significant reduction in the microorganisms.

Table 2. Organoleptic, physicochemical and bacteriologic parameters determined in leachate before (influent3) and after disinfection with oxidizing compound H_2O_2 + Ag^+(effluent3)

Parameter	Influent3	Effleuent3	removal %
Color (mg/L PtCo)	1500	150	90
Turbidity (NTU)	87	15	83
pH	7.4	7.9	-
Electric conductivity (μS/cm)	11190	10520	16
$N\text{-}NH_3$ (mg/L)	893	681	24
$N\text{-}NO_2$ (mg/L)	0.72	0.70	-
$N\text{-}NO_3$ (mg/L)	60	65	-
BOD_5 (mgO_2/L)	247	146	41
Heterotrophic bacteria $\log_{10}$CFU/mL	4.75	1.45	70
Total coliforms$\log_{10}$CFU/mL	3.38	0.62	82

Discussion

Disposal of leachate always pose an ecologic problem because its physico-chemical and epidemiologic-epizootic composition presents a hygienic risk. The problem of leachate treatment has been existing for some time now because a universal solution has not been found. The biological method of nitrification is very efficient and cheap process to eliminate ammonia, the main pollutant in this case, but it is necessary to take into account all factors which will enable a high activity of autochthonous bacteria. A conventional physical method, such as aeration and adsorption on various adsorbents, e.g. active carbon or zeolite, frequent requires the use of additional chemicals and does not solve the environmental problem because the pollution is only transferred but not eliminated. Advanced oxidation processes have been proposed in recent years as an effective method for mineralization of recalcitrant organics in landfill leachate (Wiszniowski et al., 2006).

It can be concluded that efficient removal of ammonium (main pollutant in the examined leachate) can be accomplished by addition of phosphate and natural zeolite followed by aeration of leacheate. A final disinfection treatment of the leachate with hydrogen peroxide in final concentration of 1500 ppm, results in efficient hygienization in terms of improved organoleptic and environmentally relevant physicochemical and microbiologic parameters as well as disinfectant by products.

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