SOLUTIONS AND EQUIPMENT FOR LEACHATE TREATMENT

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Without a proper waste management, leachate may contaminate the environmental; landfill gas can be toxic and lead to global warming and explosion and landfill wastewater can pollute the land and surrounding waters. The major factors, which affect the production of leachate and landfill gas are waste type, pH, moisture content, particle size and density, temperature, landfill type etc. Concentrations of various substances occurring in leachate are too high to be discharged to surface water or into a sewer system. These concentrations, therefore, have to be reduced by removal / treatment. Common toxic components in leachate are COD, BOD, ammonia, heavy metals etc. Process combinations for the treatment of landfill leachate have been thoroughly tried and tested over the past years by many researchers. A new solution and equipment were proposed by a team of researchers from DFR Systems SRL in order to treat the leachate. Several treatment stages were implemented in the wastewater treatment technological flux: physical treatment, biological treatment (with artificial mobile support), ultrafiltration, dissolved air flotation, UV disinfection etc. The new technology was tested on a lab-scale facility and the results were encouraging. In the present paper are presented the obtained results as well as the treatment technology and equipment.

Keywords: leachate, wastewater treatment, equipment for leachate treatment

INTRODUCTION

This paper aims to present the problem of collection and treatment of leachate from municipal landfills to reduce pollution levels by developing modern technologies and equipment/installations for leachate treatment. In order to treat the leachate is very important to know its composition that is influenced by the following factors: the composition of the waste being deposited and the degree of decomposition; the age of the landfill; mass of humidity existing in wastes; temperature; storage system and technological solutions for compacting, stratification, coating, period of execution etc.

For Romania, the general characteristics of the landfills in the country are the lack of treatment before storing and poor selective extraction by collecting a small percentage of recyclable components / recoverable and this in a narrow range (cardboard, paper, plastics and metals). Leachate generated in different phases has different quality characteristics. The acid phase is characterized by an acidic pH and a high content of volatile organic compounds like CO_2 and H_2S. The formation of volatile fatty acids is the main reason for the low pH and high organic content. Methane phase under aerobic or anaerobic conditions is characterized by a neutral pH and slow rate of fermentation. The main emissions are methane and CO_2. The organic matter content of the leachate is expressed through the necessary biochemical oxygen demand (BOD_5), total organic carbon (TOC) and chemical oxygen demand (COD).

It should be noted that metals do not significantly vary during different phases. Elements such as sodium, sodium chloride, AOX (halogenated) show the dependence of conditions prevailing circumstances for degradation. The same cannot be said of phosphorus whose concentrations decrease from the acid to the metanogenic stage.

The nitrogen concentrations show a downward trend explained by nitrification and denitrification processes in the warehouse and / or the incorporation of nitrogen in biomass. Variations are found throughout the browsing phase pH, BOD_5, COD, magnesium, calcium, iron, manganese and zinc. With the exception of pH most of the components have a higher level in the acid phase than in the metanogenic phase. Other indicators showing significant variations in the acid phase are: total organic carbon (TOC), conductivity, nitrogen, phosphorus, sodium, sulfur, potassium and arsenic. There are some exceptions, such as lead, copper, aluminum and barium which may have higher concentrations of methane during the stage.

The amount of leachate and its degree of contamination are dependent on: the type of waste deposited, deposit age, landfill height, meteorological characteristics of the location area, quality of deposit isolation.

a. The variation of leachate composition - high degree of waste composition diversification generates a similar high degree of leachate composition diversification.

b. Age deposit - over time, the leachate content (consisting in water, dissolved gases and biomass) vary. Leachate quantitative increase in the first 4 years, decrease until the 8^{th} year and reaches a constant value that represents ≈1‰ of the maximum amount.

c. Temperature - the temperature affects biological processes and chemical reactions that occur in the deposit. Deposits with heights/depths greater than 15 m are not influenced by seasonal temperature variations.

d. The available oxygen content of the waste. Landfill and release of chemicals occurs are different in aerobic or anaerobic conditions. Deposits with thicker layers of waste are favored to anaerobic conditions.

e. Moisture waste. Location deposits in areas characterized by predominantly rainy weather generates a higher quantity of leachate. Climatic conditions lead also to leachate seasonal variations.

f. Homogeneity of mass storage. A municipal landfill is not homogeneous and several wastes adsorb water more easily (cardboard or paper) and at the other extreme waste such as plastics, glass or construction waste do not adsorb water.

A typical concentration of the average leachate pollutants is presented in Table 1.

Table 1. The main physico-chemical characteristics of an average leachate

	Values	Nature of pollution
pH	6.1	Acid
COD	1650 mg/l	Organic pollution
Organic compounds	4800 mg/l	Organic pollution
Na; K;	2900 mg/l	Mineral pollution
Ca; Mg;	2000 mg/l	Mineral pollution
Cl; SO_4;	4800 mg/l	Mineral pollution
NH_4	650 mg/l	Mineral pollution
Fosfor total	6 mg/l	Mineral pollution
Fe	900 mg/l	Metal pollution
Mn	25 mg/l	Metal pollution
Zn	10 mg/l	Metal pollution
Other metals like: Co, Ni, Cu, Cr, Pb, Mo, As, Hg	10 mg/l	Metal pollution

MATERIALS AND METHODS

Taking into account the large number of the pollutants present in leachates, a special technological flux must be conceived in order to remove all the pollutants mentioned in Tabel 1. In this way the new leachate treatment technology was based on several stages: removal, of coarse solids; removal of fine solids; leachate homogenization and pH correction; filter; biological stage; dissolved flotation unit; settler; membrane biofilter; UV disinfection. Additional chemical stage can be introduced in the mentioned technological treatment flux. A special attention was given to the final settler because this equipment must remove both the foam resulted from flotation and suspended solids. The main purpose of sedimentation is to remove suspended solids (organic matter, very fine sand, etc.), thus decreasing loading subsequent purification steps (Metcalf and Eddy, 2003). The rate of settling in clarifiers depends on the size and density of the particles and the degree of flocculation (Figure 1). For a correct designing mathematical modelling and numerical simulations were used.

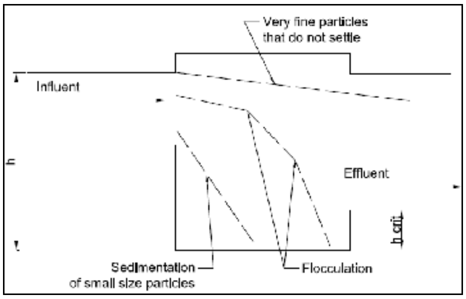

Figure 1. The rate of settling depending of particles size

The vertical section of the new vertical settler conceived, designed and patented is presented in Figure 2 (Moga, 2014). The vertical settler in used for the separation of phases from multiphase fluids. The principal characteristic of multiphase fluids (mixture) is the fact that, in static conditions, due to different specific weight, the phases will separate by gravity in two vertical directions: phases heavier than water will separate in a descending direction – in a process called sedimentation, and phases lighter than water will separate in the ascending direction, with floating materials rising to the surface – in a process called flotation.

The low flow velocity in a settler allows settleable particles to sink to the bottom, while constituents lighter than water float to the surface.

Sedimentation is also used for the removal of grit (pre-treatement technologies), for secondary clarification in activated sludge treatment, after chemical coagulation / precipitation, or for sludge thickening. Settlers can achieve a significant initial reduction in suspended solids (50-70% removal) and organic material (20-40% BOD removal) and ensure that these constituents do not impair subsequent treatment processes. The main purpose of a *settler* is to facilitate sedimentation by reducing the velocity and turbulence of the *wastewater* stream. Settlers are typically designed for a *hydraulic retention time* of 1.5-2.5 h. Less time is needed if the *BOD* level should not be too low for the following biological step. The tank should be designed to ensure satisfactory performance at peak flow.

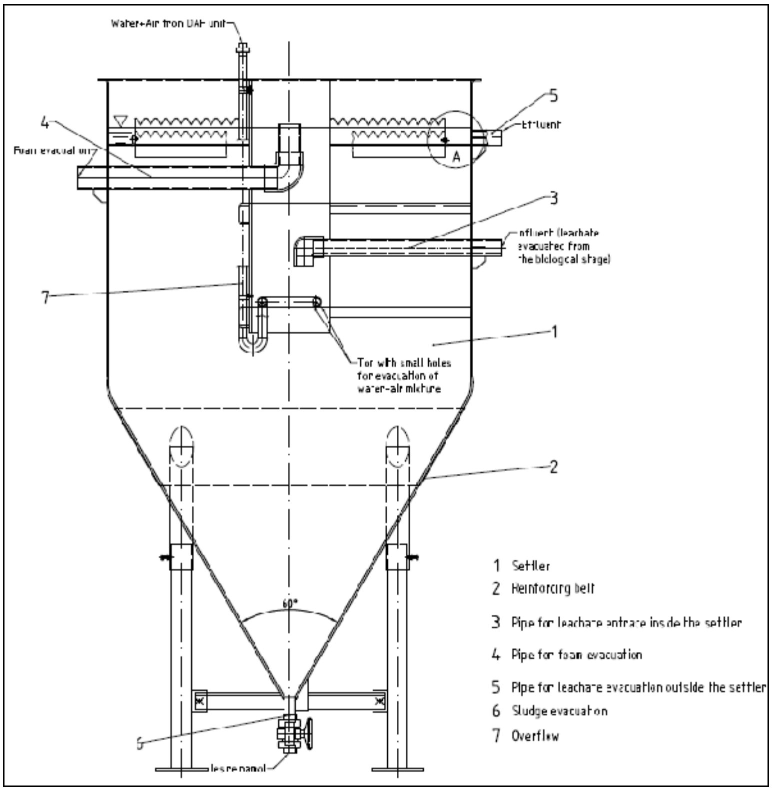

Figure 2. Vertical section of the new settler used for leachate treatment

EXPERIMENTAL

A laboratory installation was conceived, designed and realized. The technological flux of the developed facility is presented in figure 3. The biological treatment stage is also innovative and Mobile Bed Biofilm Reactor process is implemented. This technology utilizes free-moving biofilm carriers that represents a future evolution of the activated sludge process that allows a greater pollutant removal degree in smaller systems (Zafarzadeh *et al*., 2008). The biofilm grows protected within small plastic carriers, which are carefully designed with high internal surface area. These biofilm carriers are suspended and mixed throughout the water phase. The wastewater treatment with bio-media consists in adding biofilm carriers (small cylindrical shaped polyethylene carrier elements with specific density of 0.96 g/cm^3) in aerated or anoxic basins to support biofilm growth. When the microorganisms in the biological film die, the film breaks up and peels off from the solid support being carried away by the liquid current. The destroyed cellular material is directed to the vertical settler and detained as sludge. Hence, the need for the hydraulic scheme to include a secondary settling tank/filter (American Water Works Association, 2000). The new settler was included in the leachate treatment.

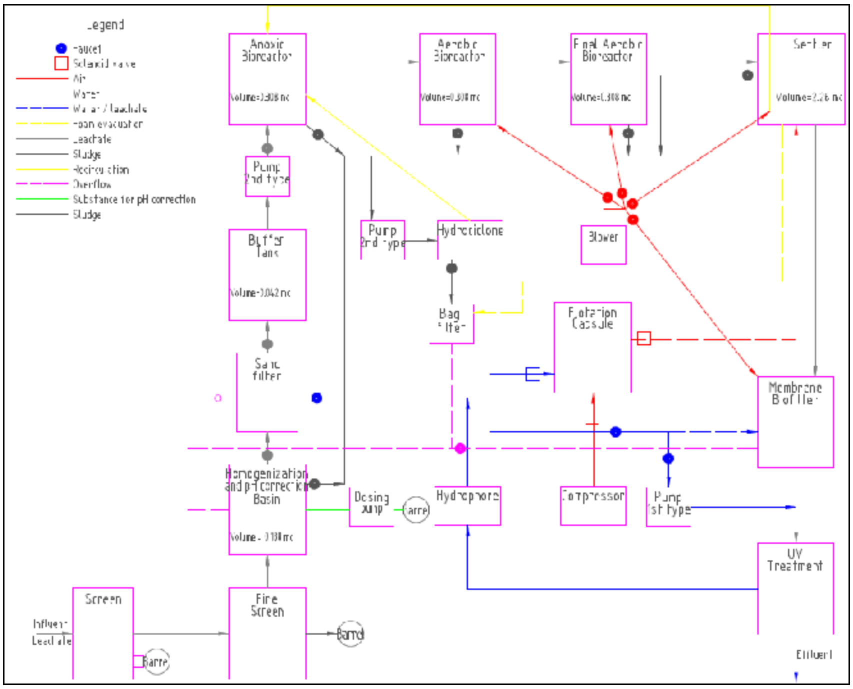

Figure 3. Technological flux of the laboratory installation for the leachate treatment

RESULTS AND DISCUSSIONS

The leachate flow-rate was established at 0.02 m^3/h. Experimental researched and the process efficiency of the laboratory leachate treatment plant was determined. Analysis for both influent and effluent were realized and the main quality indicators were measured. For BOD and COD removal an efficiency over 90% was obtained and all the quality indicators were significantly reduced.

CONCLUSIONS

Given the obtained results (the reduction of the leachate parameters values) from the experimental researches realised in laboratory conditions, the proposed technology may constitute solutions to modernize existing leachate treatment plants. Already some parts of the leachate treatment plant (the system of dissolved air flotation and vertical settler) have been tested with other types of wastewater (brewery) achieving a high efficiency of treatment and reduce the investment costs with (15-20)% compared to existing solutions for wastewater treatment.

Currently there are two patents for the components of the leachate treatment plant. The research team aims to develop technology in the future, analyzing the possibility of introducing advanced treatment steps to achieve a high treatment standards specified by the NTPA001 (effluent discharge into natural receivers).

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