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ADVANCED TREATMENT OF LEACHATE BY USING AEROBIC/ANOXIC MBR SYSTEM FOLLOWED BY A NANOFILTRATION PROCESS. A CASE STUDY IN ISTANBUL KOMURCUODA LEACHATE TREATMENT PLANT

The most common municipal solid waste (MSW) disposal method is sanitary landfill. The major disadvantage of this method is the production of highly contaminated leachate. Not only physico-chemical but also biological methods are sufficient alone in order to remove organics from leachate to get high effluent quality. Integrated processes that use physicochemical and biological methods at the same time like membrane bioreactors (MBRs) have been mostly employed in landfill leachate treatment in last decade. In this study, the removal of organic material using aerobic/anoxic MBR system followed by a nanofiltration process was evaluated.

1. INTRODUCTION

Disposal of municipal solid waste is the main component of the solid waste management system. Several solid waste disposal methods are in use such as landfilling, incineration, composting, and recycling. Sanitary landfill is the most common municipal solid waste (MSW) disposal method having such advantages as simple disposal procedure, low cost, and landscape-restoring effect on holes from mineral workings [1]. However, the production of highly contaminated leachate is a major disadvantage of this method [2]. Discharge of landfill leachate could lead to serious environmental problems, due to the fact that leachate contains a large amount of organic matter (both biodegradable and nonbiodegradable carbon), ammonia-nitrogen, heavy metals, chlo-

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minated organic and inorganic salts [3]. Therefore, the generated leachate must be collected and efficiently treated, before being discharged back to the environment [4]. In general, the self-purification capacity of surface water is insufficient for concentrated discharges of leachate and therefore treatment in a wastewater treatment plant or biological leachate treatment plant has to reduce oxygen consumption of the leachate. In the case of discharge to more critical receiving water bodies denitrification and phosphorous removal is necessary. The next step is removal of color, heavy metals and organic micro-pollutants by oxidation (peroxide, ozone), activated carbon systems, coagulation or nanofiltration. If the receiving water cannot dilute the salt content in a proper way, desalination of the leachate is necessary by reverse osmosis, electro-dialysis or evaporation. Nanofiltration (NF) is a promising complementary treatment technique for leachate treatment [5]. Removal of organic material based on chemical oxygen demand (COD) and ammonium from leachate is the usual prerequisite before discharging the leachate into the receiving water bodies [6].

On the European side of Istanbul, 8 thousand tons of solid waste is being collected daily in the landfill area established on 75 ha in Odayeri/Gokturk. In present, daily leachate production of Odayeri is 2000 m³. On the Asian side of Istanbul, 4 thousand tons of solid waste is being collected daily in the landfill area established on 100 ha in Komurcuoda/Karakiraz. At present, daily leachate production of Komurcuoda is 1200 m³. Eventually, Istanbul city produces large amounts of leachate and that highly contaminated leachate has to be treated in order to remove biodegradable and recalcitrant contaminants and protect the environment and public health.

Physicochemical and biological methods could be employed by means of MSW landfill leachate treatment [4]. Biological methods applied to remove organic matter and ammonium nitrogen are aerobic, anaerobic and anoxic [7]. Physicochemical methods such as coagulation-flocculation, activated carbon adsorption, chemical oxidation, membrane filtration including reverse osmosis and nanofiltration, have also been utilized to treat leachates [7, 8]. However not only physicochemical but also biological methods are not sufficient alone in order to remove organics from leachate to get high effluent quality [8]. Integrated processes that use physicochemical and biological methods at the same time like membrane bioreactors (MBRs) have been mostly employed in landfill leachate treatment in the last decade [2, 8-14].

A membrane bioreactor (MBR) is a compact-built purification system combining a biological degradation step with a membrane separation step instead of a settling tank. Presently, two basic MBR systems can be distinguished using these principles. One of them is side-stream system in which membranes are placed outside the bioreactor. The membranes are horizontally or vertically placed tubular ones fed at the inside. The other one is the submerged system – membranes are submerged in (a separate part of the) the bioreactor [5].

The aim of this study is to analyse the characteristics of the leachate generated at the Komurcuoda landfill site on the Asian side of Istanbul, Turkey. Furthermore, the

removal of organic material using aerobic/anoxic MBR system followed by a nanofiltration process was evaluated by means of chemical oxygen demand (COD), total nitrogen (TN-N) and ammonium nitrogen ($\text{NH}_4\text{-N}$) removal.

2. MATERIALS AND METHODS

Istanbul City, having the biggest population of Turkey, has two landfill areas located both on its Asian (Komurcuoda) and European (Odayeri) sides. Istanbul Metropolitan Municipality Environmental Protection and Waste Materials Recycling Industry and Trade Co. (ISTAC), is one of the economic enterprises of Istanbul metropolitan municipality and operating landfills, composting plants and several other recycling plants. ISTAC Co. within the scope of solid waste project of Istanbul metropolitan municipality provides services for waste management, production of compost fertilizer, recycling of wastes, disposal of them via landfilling, electric energy generation from landfills, transportation of medical waste and their disposal via incineration.

This is a case study of the Asian side of Istanbul city MSW landfill leachate treatment plant located at Komurcuoda in Turkey. The existing treatment plant has the capacity of $1200 \text{ m}^3\cdot\text{day}^{-1}$ and the process is composed of ammonia stripping tank, primary sedimentation tank, and aerobic/anoxic MBR system followed by nanofiltration (NF) process (Fig. 1). Side-stream MBR system contains an aerobic/anoxic tank integrated with ultrafiltration (UF) process.

On the Asian side of Istanbul, 4 thousand tons of solid waste is being collected daily in the landfill in Komurcuoda and leachate production of it is about 1200 m^3 . Table 1 shows leachate characteristics of influent wastewater of Komurcuoda landfill leachate treatment plant.

Ammonia stripping is used in order to remove toxic effects of ammonia on biological systems in Komurcuoda landfill leachate treatment plant that uses aerobic/anoxic MBR followed by NF process to meet the effluent criteria. Aerobic/anoxic MBR system is used for nitrification and denitrification processes. Finally removal of both organics and nitrogen forms has been made by means of this system. After the aerobic/anoxic MBR system NF process takes place in the plant. NF is a membrane technique situated between the well known ultrafiltration (UF) and reverse osmosis systems and is commonly used to treat industrial wastewater and produce potable water from groundwater and surface water [15]. The advantages of the nanofiltration system are the low pressure, high recovery and high retention of COD, heavy metals and organic micropollutants [5].

Microfiltration and ultrafiltration membrane modules applied in water treatment are usually capillary or tubular modules, while plate and frame modules are also used for waste water treatment. Nanofiltration and reverse osmosis membranes are usually spiral wound modules [5]. The membrane acts as a selective barrier enabling some

components to pass and others not to. The driving force for this process in water treatment is usually restricted to a pressure difference.

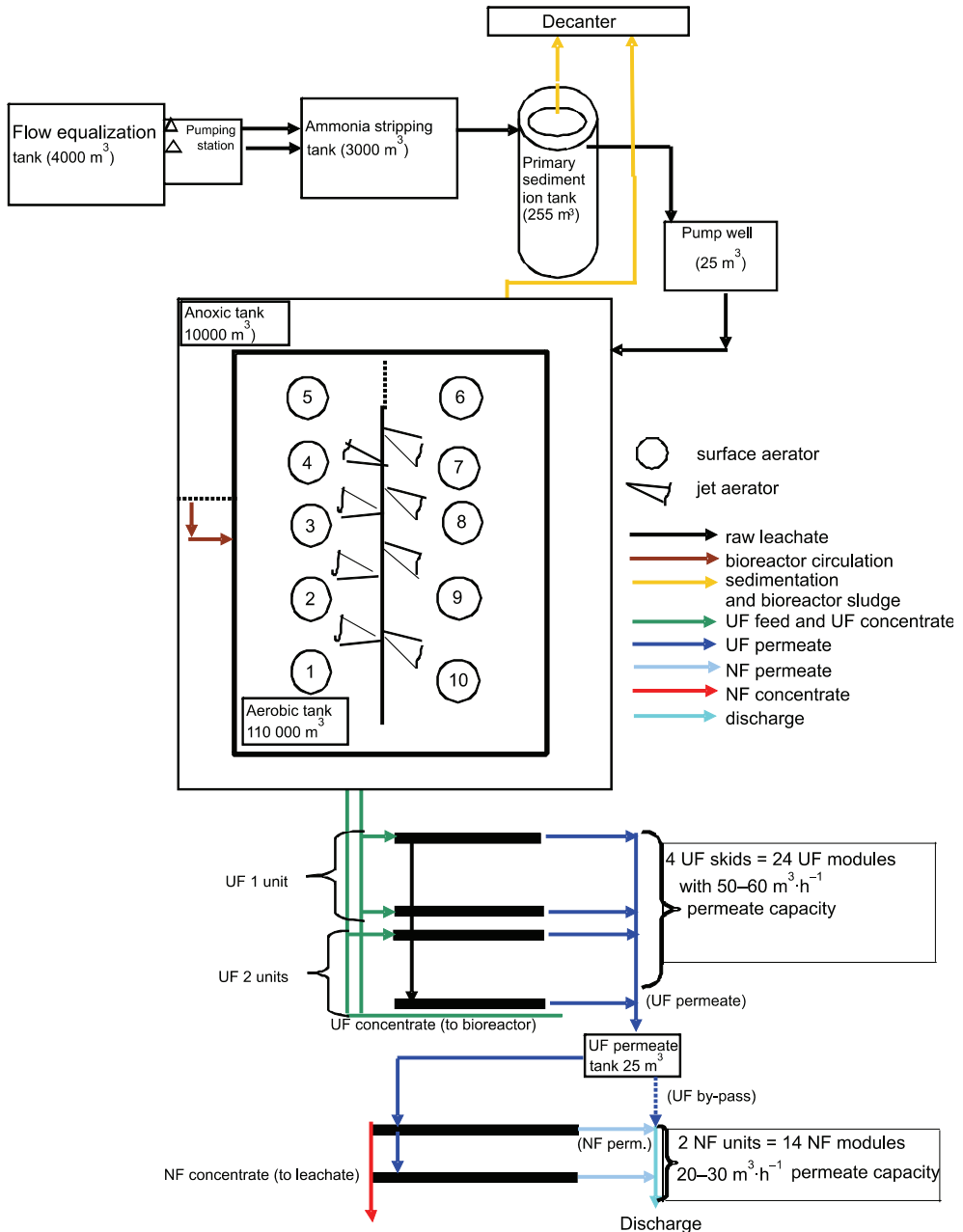


Fig. 1. Process flow diagram

Table 1

Leachate characteristics

Parameter	Unit	Raw leachate	
		Minimum	Maximum
pH		5.5	8.5
COD	mg·l ⁻¹	3.000	40.000
BOD ₅		3.000	13.000
Temperature	°C	15	20
P-total	mg·l ⁻¹		<5
N-total		2.000	5.000
TKN		2.000	5.000
TSS		300	1.500
SO ₄		5	500
Total hardness		mg CaCO ₃ ·l ⁻¹	1.400
Conductivity	μS·cm ⁻¹	30.000	40.000
Total alkalinity	mg CaCO ₃ ·l ⁻¹	8.000	13.000

Membranes used in Istanbul Komurcuoda Landfill Leachate Treatment Plant with the 30 nm pore size and the pressure driving force UF operated at the pressure of 6.4 bar as well as those with pressure driving force NF operated at the pressure of 14–15 bar were cleaned by flushing for short intervals and by clean-in-place (CIP) chemicals such as sodium hypochlorite, citric acid, sodium hydroxide, and hydrogen chloride when serious flux decline has been attained. Flushing process takes 3–5 min with 2–3 h interval. CIP process takes 3–4 h with much longer interval.

3. RESULTS AND DISCUSSION

The treatment results in terms of COD, TN, NH₄⁺-N concentrations of influent, MBR effluent, and NF permeate are shown in Figs. 2–4, respectively. The average influent COD of the leachate of ca. 24 000 mg·l⁻¹ was treated to the level of 1500 mg·l⁻¹ and 250 mg·l⁻¹ after MBR and NF, respectively with the final removal rate of about 99%. Figure 2 shows influent, MBR effluent, and NF permeate COD concentrations.

Wastewaters containing 1.000 or more mg N·l⁻¹, either as NH₄⁺-N or organic N causes major difficulties in nitrification process with the inhibition of *Nitrobacter* species [9]. The average influent TN-N of the leachate of ca. 2.890 mg·l⁻¹ was treated to the level of 160 mg·l⁻¹ and 121 mg·l⁻¹ after MBR and NF, respectively with the final removal rate of about 96% despite unbalanced carbon to nitrogen ratio (C/N) of 2.0 as BOD₅ and TN base. Figure 3 shows influent, MBR effluent, and NF permeate TN-N concentrations. Researchers use BOD₅/COD ratio to describe the biodegradability level of materials by which organic matter containing wastewater is readily broken

down in the environment and untreated materials such as raw water, wastewater and landfill leachate the BOD_5/COD ratio is higher than 0.5 [16]. In “fresh” leachate from young landfills (the acid-phase landfills), the concentrations of organic compounds (BOD_5 and COD) are very high, whereas in “mature” leachate from old landfills (methanogenic-phase landfills), the levels of organic matter are substantially lower [4].

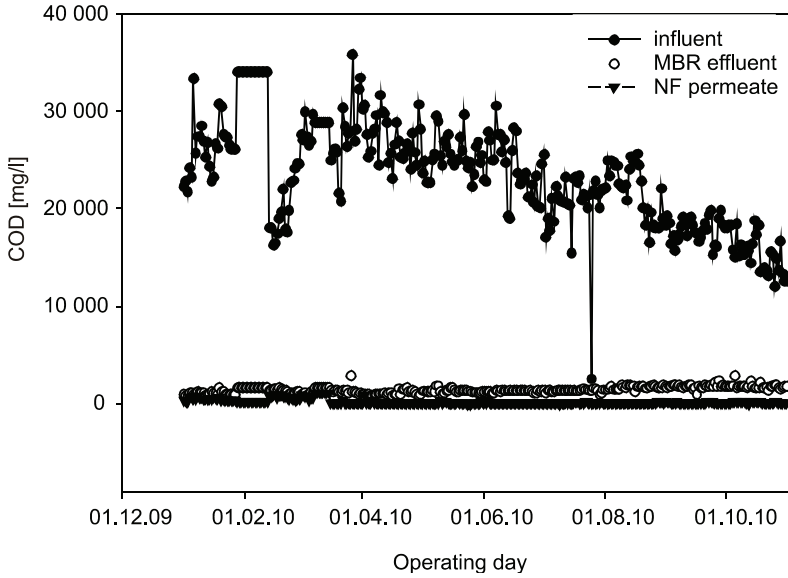


Fig. 2. COD in the leachate

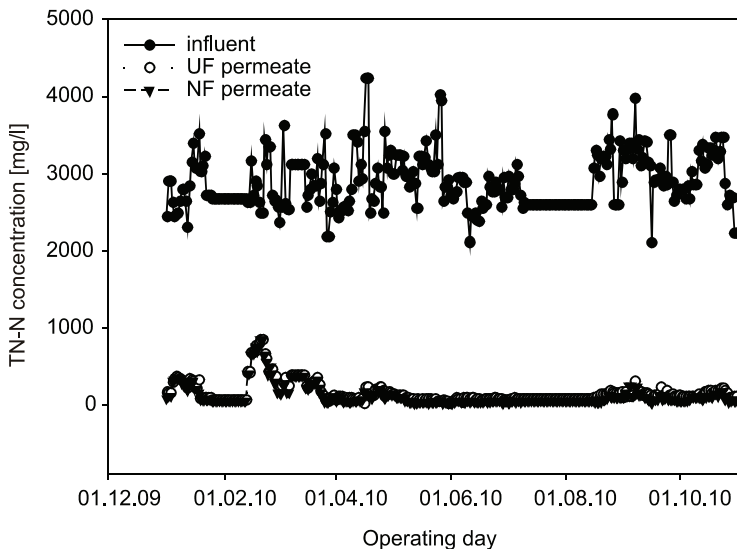


Fig. 3. Total nitrogen concentration in the leachate

The average influent $\text{NH}_4^+\text{-N}$ of the leachate of about $2,313 \text{ mg}\cdot\text{l}^{-1}$ was treated to the level of $35 \text{ mg}\cdot\text{l}^{-1}$ after MBR with the removal rate of about 98%. Influent, and MBR effluent $\text{NH}_4^+\text{-N}$ concentrations are shown in Fig. 4.

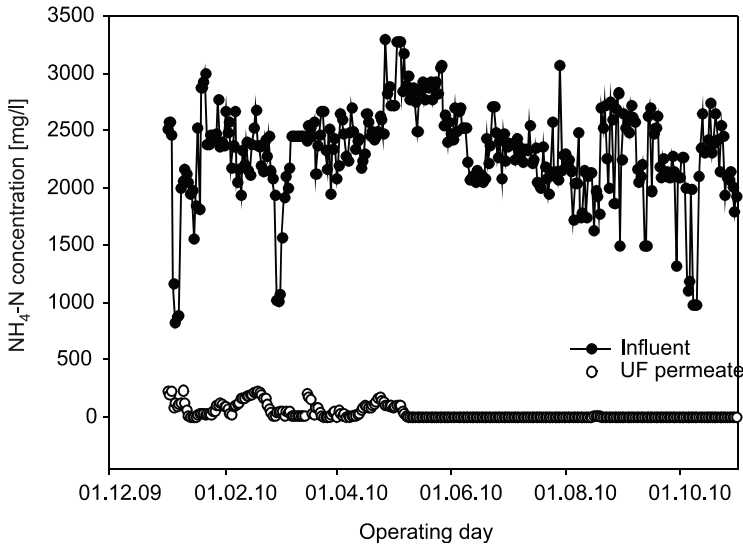


Fig. 4. $\text{NH}_4\text{-N}$ concentration in the leachate

Finally it may be concluded that high pollution load landfill leachate could be treated efficiently using aerobic/anoxic MBR system followed by a NF process.

4. CONCLUSION

Biological treatability of Komurcuoda landfill leachate in aerobic/anoxic MBR systems followed by a nanofiltration process has been investigated. Biodegradable organic content of leachate decreases and its nitrogenous content increases due to the landfill age. Therefore biological nitrogen removal by nitrification/denitrification process is hard. However the integrated membrane process which was used in this study showed high removal efficiency with high effluent quality. Therefore it seems that an integrated membrane process greatly enhances treatment efficiency and removes organic and nitrogenous matter from landfill leachate.

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