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Optimization of SBR system for sanitary landfill leachate treatment in Egypt

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ABSTRACT
Solid waste problem is considered one of the most challenging problems that Egypt suffers. Landfill is considered a simple solution to overcome such as problem. Sanitary landfill produces leachate which has bad side effects because it contains difficult decomposition material and bad odors. So, there must be a solution to treat it and dispose it safely. This research presented a solution for leachate treatment using sequential batch reactor "SBR". The samples were collecting from sanitary land fill of Elhammam city that collects solid waste from Alexandria, samples of leachate ponds were taken in 15 containers of 20 liters which transferred to the workplace in order to apply the experiments on it. The physico-chemical parameters (COD, BOD, TSS, TKN, TP, PH, and NH3-H) achieved high percent removal as (97.9%, 98%, 98.3%, 99.2%, 98.4%, 99.6%) respectively, were done by Egyptian national research center

KEYWORDS:

INTRODUCTION

Different methods of solid waste disposal are well known such as landfill, refuse composting, incineration and pyrogentation. At present, in most cities, the most basic and important part of bio-waste recycling is composting. Main attention with composting is pollution of leachate [10].

Leachate consists of different compounds including organic and inorganic compounds, these compounds may be suspended and/or dissolved. These pollutants have negative impact on the environment and cause potential deterioration for surface and groundwater. In order to reduce this negative impact, proper leachate treatment is today's challenge. There are two main factors characterizing a leachate, the generated volume and its composition. Many parameters affecting these two factors such as waste type, conditions of climate, and operation mode [4].

Nowadays, biological treatment of leachate has an increasing interest. Biological treatment processes are classified as aerobic and anaerobic. In aerobic treatment, the organic pollutants converted into CO_2 and sludge, while in anaerobic treatment, the organic pollutants converted into a mixture CH_4 and CO_2 (biogas) and small amount of sludge. Application of biological treatment process in leachate treatment was very effective for removing of nitrogenous and organic pollutants especially when the ratio ofbiochemical oxygen demand/chemical oxygen demand has a high value (>0.5) [2].

The widely studied and adopted aerobic biological treatment based on suspended-growth of biomass, including aerated lagoons, activated sludge and sequencing batch reactor (SBR). Irvine and Davis (1971) introduced SBR for description of a specific kind of activated sludge designed for wastewater treatment generated during production of carbohydrates. SBR has a higher controllability and flexibility allowing rapid adjustment for changes in influent characteristics. It was proved that, SBR operation systems with short solid retention times, was useful for treatment of wastewater containing heavy metals such as lead and nickel [5].

Different strains of bacteria such as *Alcaligenes eutrophus*, *Pseudomonas pseudoalcaligenes*, *Pseudomonas mendocina*, *Arthrobacter* sp., *Geobacillus thermodenitrificans*, *Micrococcus luteus* and*Bacillus* sp showed high abilities for leachate treatment and removal of heavy metals [6,7,11].

The main aim of the present research is to study the improvement of leachate wastewater treatment through addition of Micrococcus bacteria into a mini-model SBR unit during aeration stage.

MATERIAL AND METHODS

1. Landfill site description:

The samples were collected from the sanitary Landfill located in the Elhammam city, Alexandria governorate, Egypt. Elhammem city is located 80 Km at the west of Alexandria governorate, and the current area of the landfill equal about 138 acres, with a height estimated from 25 to 30 meter. The landfill receives about 510.000 ton of wastes every 6 months at least, and the amount of wastes increases in the summer. The landfill has been receiving wastes since 2003. At present, the landfill is composed of 10 cells used for burial of wastes, as shown in Figure (1).

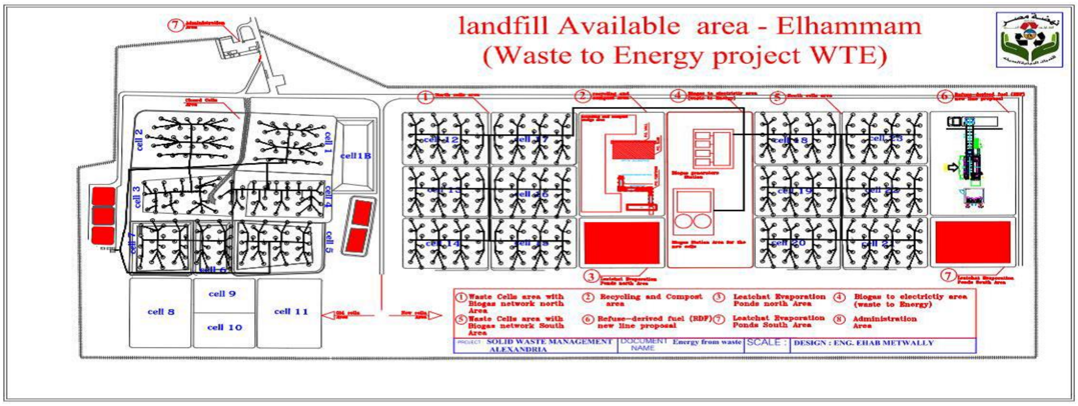

Fig. 1: Schematic diagram of Elhammam sanitary landfill.

2. Sampling:

Sterile plastic containers (10 liters volume) were used for leachate samples collection from leachate ponds at Elhammam sanitary landfill. After collection, samples containers were transferred immediately for further treatment and analysis using the pilot plant model as shown in (Figure 2).

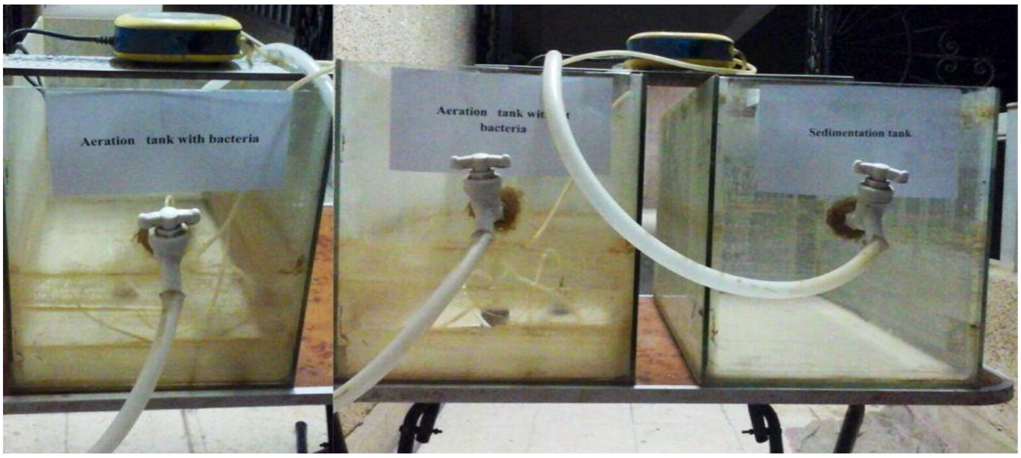

Fig. 2: A photograph of the pilot plant

3. Description of the pilot plant:

The unit consists of three tanks as shown in Figure (3).

1. First tank is a primary sedimentation tank, the tank is rectangle in shape, with a dimension 60*30*30 cm. A volume of 45 liters of leachate wastewater was placed inside the tank for precipitation. With Retention time was 12 hours.

2. Second tank is the first aeration tank with dimensions of 60*30*30 cm. The leachate inside the tank was aerated for 12 hours to activate the natural aerobic bacteria in order to perform their function in oxidizing and fixing organic materials. Aeration and flipping has been done by using the compressed and diffused air method through perforated air pipes. Retention time was 12 hours.

3. Third tank is the second aeration tank with dimensions of 60*30*30 cm. Micrococcus bacteria was added inside the tank (120 mL / 10 liters' leachate). Retention time was 12 hours.

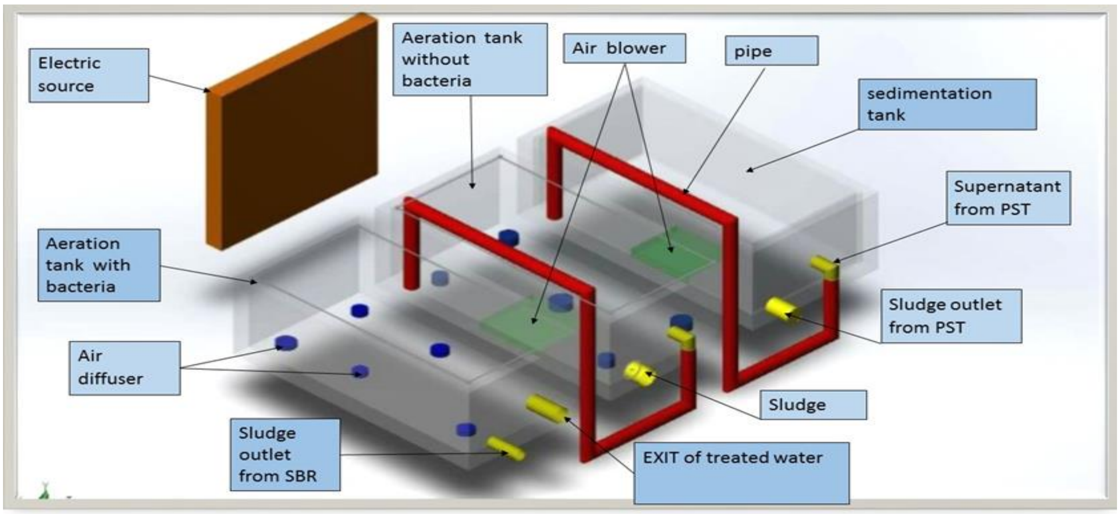

Fig. 3: A schematic diagram of the pilot plant

4. Physico-chemical parameters:

Three different samples were collected from each tank. Samples were collected after constant retention times at 6, 9 and 12 hours. For all samples, physicochemical parameters were measured including chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS), pH, total Kjeldahl nitrogen (TKN), total phosphorus (TP) and ammonia-nitrogen (NH_3-N). All measured parameters were carried out according to [3].

RESULTS AND DISCUSSION

1. Characterization of raw leachate:

Results obtained in Table (1) summarized the physicochemical characteristics of collected raw leachate. It was clear that, raw leachate was highly polluted. High values of COD and BOD indicated that organic matters were highly concentrated in leachate. pH of leachate was neutral. In addition, it was clear that leachate was rich of both nitrogen and phosphorus. Leachate also was very dark in color indicating high suspended matters.

Table 1: Characterization of raw leachate.

Raw leachate		
Parameter	Unit	Value
COD	mg/l	79000
BOD	mgO_2/l	35000
pH	--	7.5
TSS	mg/l	5380
TKN	mg/l	9100
NH_3-N	mg/l	5800
TP	mg/l	1000

2. Characterization of SBR pilot plant unit:

The SBR pilot plant unit consists of three tanks as described previously. First tank was an ordinary sedimentation tank with retention time 12 hours. Three samples were collected and physico-chemically examined after 6, 9, and 12 hours. Results in Figure (4) and Table (2) described the obtained results from first tank compared to original raw leachate. It was clear that, there was great removal for all measured physicochemical parameters. Removal percent was almost around 60% after 12 hours' retention time for all measured parameters. However, leachate still contain very high concentrations of organic pollutants and still colored and turbid. Sedimentation tank has no aeration, aerobic bacteria naturally live in leachate has no enough oxygen for utilization of organic matter. The utilization pathways of organic matter was so slow even after 12 hours retention time. This was in accordance with the studies done by Abd El Haleem et al., [1] who studied the ability of modified SBR system for leachate treatment. Their obtained results proved the weak ability of sedimentation tank for removal of organic pollutants form sanitary landfill leachate.

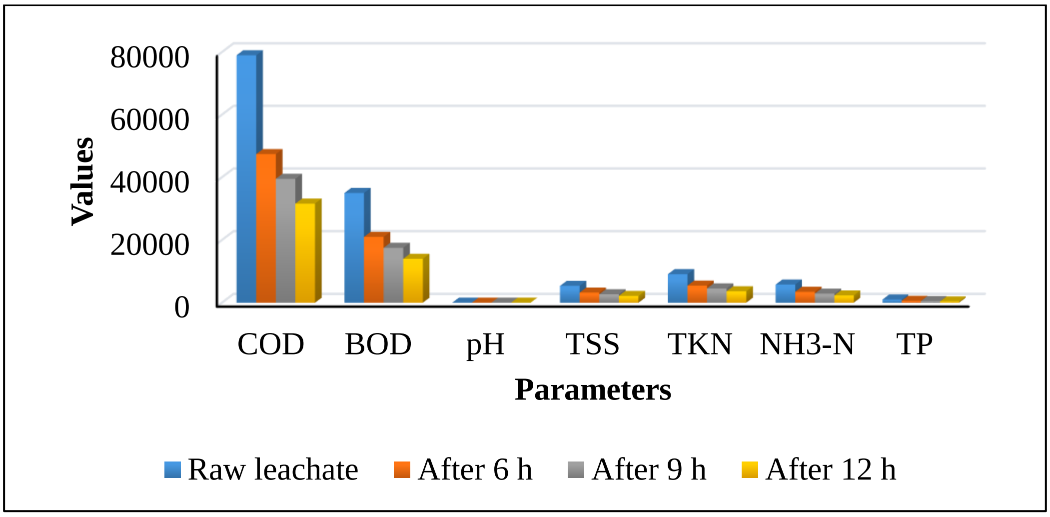

Fig. 4: Removal of pollutants during sedimentation tank.

Table 2: The results of samples after sedimentation

Parameter	Raw leachate	Sedimentation tank			Total removal efficiency of Sedimentation stage
		6 hours	9 hours	12 hours	
COD	79000	47400	39500	31600	60%
BOD	35000	21000	17500	14000	60%
PH	7.5	7.5	7.5	7.5	……..
TSS	5380	3228	2690	2045	62%
NH_3-N	5800	3480	2900	2378	59%
TKN	9100	5460	4550	3549	61%
TP	1000	600	500	380	62%
Average					60%

However, in the second tank, sequential batch reactor "SBR" tank without bacterial additives, there was a noticed decrease in organic pollutants concentrations after retention time 12 hours. The total Removal efficiency percent of all examined physico-chemical parameters ranged from 90% to 94.9% indicating ability of sequential batch reactor "SBR" tank without bacterial additives for treatment of leachate (Figure 5). Also, it was clear that, by increasing retention time, removal percent of organic pollutants increased. Suspended solids removed by 94.9% after retention time 12 hours, converting leachate to be more clear as shown in table 3. The high ability of sequential batch reactor "SBR" tank may be attributed to presence of healthy natural bacteria present in leachate which utilize organic pollutants in presence of aeration as a source of oxygen which enhance growth and reproduction of aerobic bacteria which produce more feed on organic matters. Increase in bacterial numbers make suspended particles more heavily in weight allowing these suspended particles to be settled. Many previous studied indicated the capability of sequential batch reactor "SBR" tank for removal of organic pollutants from leachate [8,1,9,2].

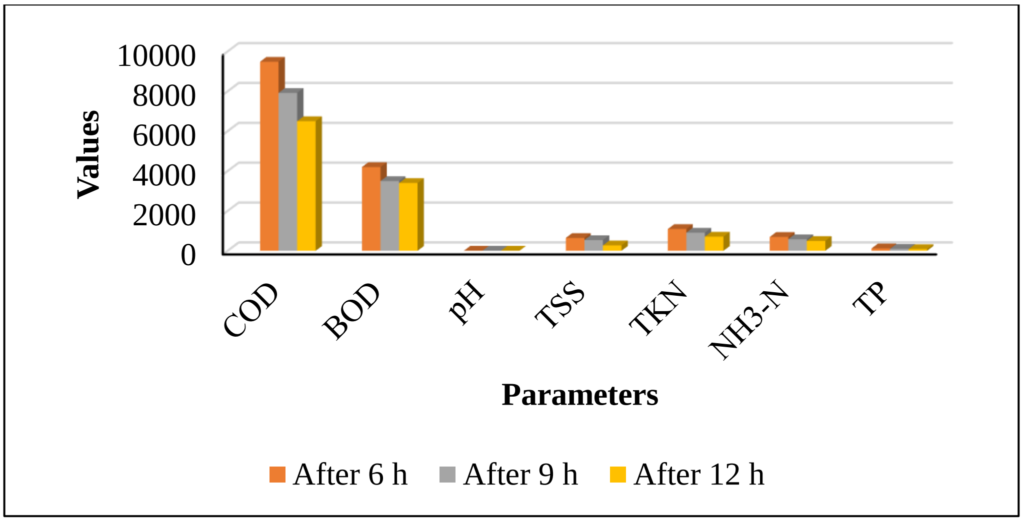

Fig. 5: Removal of pollutants during aeration tank without Micrococcus bacteria.

Table 3: The results of samples after SBR

Parameter	Raw leachate	Influent of SBR	SBR without adding bacteria			Total removal efficiency of SBR stage	Total removal efficiency of SBR and sedimentation stage
			6 hours	9hours	12hours		
COD	79000	31600	9480	7920	6500	79.4%	91.7%
BOD	35000	14000	4200	3500	3400	75.7%	90.4%
PH	7.5	7.5	7.3	7.3	7.3	……	……
TSS	5380	2045	646	538	377	81.56%	92.9%
NH3-N	5800	2378	696	580	493	79.26%	91.5%
TKN	9100	3549	1092	910	710	79.9%	92.1%
TP	1000	380	120	100	85	77.6%	91.5%
Average							91.5%

In order to improve and enhance the capability of sequential batch reactor “SBR” tank for maximum removal of organic pollutants and more color removal of treated leachate, Micrococcus bacteria was added into third sequential batch reactor “SBR” tank as a seed inoculum (120 ml bacteria for each 10 liters leachate). Addition of Micrococcus bacteria was a try to improve the quality of treated leachate to match the Egyptian standards for reuse of treated wastewater. Micrococcus is a gram-positive heterotrophy bacteria, which can utilize both organic and inorganic compounds as food sources. Adding of Micrococcus bacteria into sequential batch reactor “SBR” tank improved the treatment process of leachate. Results in Figure (6) and table (4) showed the improvement in treatment of all measured physicochemical parameters. Removal percent increased from 91.7%, 90.2%, 94.8%, 91.5%, and 91.5% to 97.9%, 98%, 98.2%, 99.2%, 99.5%, and 98.4% for COD, BOD, TSS, TKN, NH_3-N, and TP, respectively. Final results indicated the successful addition of Micrococcus bacteria which increased the removal percent of pollutants making treated leachate matching the Egyptian standards for wastewater treatment. In addition, there was observable improvement in color and turbidity of treated leachate after addition of Micrococcus bacteria.

A microbial supplement, in contrast to chemical one, can ensure an optimal growth and activity of various types of microorganisms and, therefore, biomass can be more resistant to shock-loading, and present better sludge settling characteristics (i.e., lower sludge volume index) and better nitri®cation±denitri®cation behavior [12].

Many authors proved that, bacterial supplement into wastewater treatment during aeration stage can ensure an optimal growth and activity of various types of microorganisms and, therefore, biomass can be more resistant to shock-loading, and present better sludge settling characteristics (i.e., lower sludge volume index) and better nitrification-denitrification behavior [12,13].

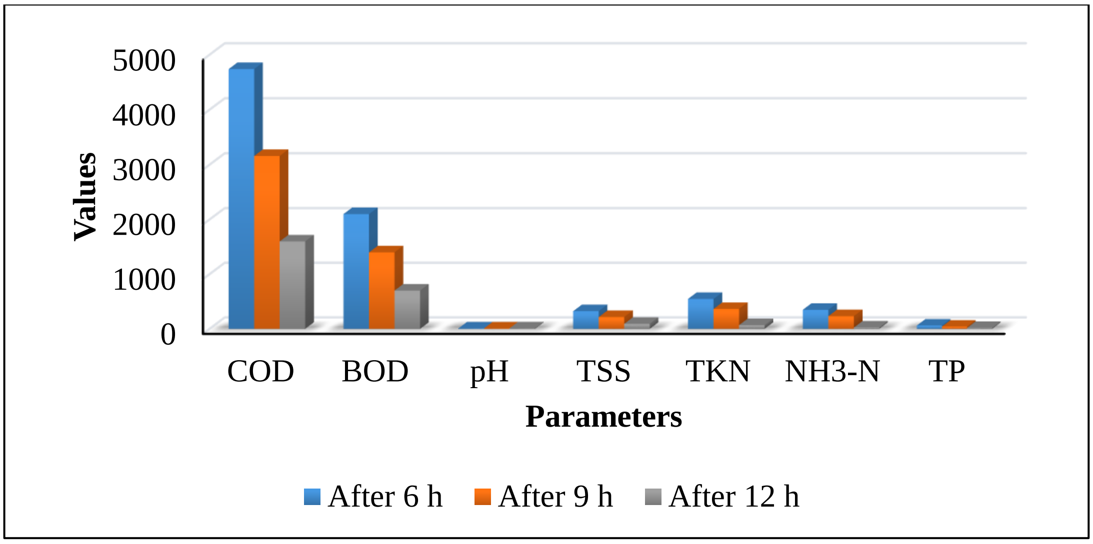

Fig. 6: Enhanced removal of pollutants after addition of Micrococcus bacteria.

Table 4: The results of SBR with bacterial additive

Parameter	Raw water	Influent of SBR without adding bacteria	SBR with bacterial additive			Removal efficiency of SBR with bacterial additive	Total removal efficiency
			6 hours	9 hours	12 hours		
COD	79000	6500	4740	3160	1600	75.38%	97.9%
BOD	35000	3400	2100	1400	700	79.41%	98%
PH	7.5	7.3	7.3	7.3	7.3	……	…..
TSS	5380	377	323	216	92	75.5%	98.3%
NH3-N	5800	493	348	232	24	95.1%	99.6%
TKN	9100	710	546	364	67	90.5%	99.2%
TP	1000	85	60	40	16	81.2%	98.4%
Average							98.5%

Conclusions:

Based on the experimental program executed in this research, the following conclusions had been reached:

- Sedimentation stage is important as a pretreatment of the landfill leachate. It reduces the physicochemical properties of the leachate COD, BOD, and TSS by 60 %.
- In case of using the SBR without bacterial additive the COD, BOD, and TSS decreased by 91.7%, 90.4%, and 92.9% respectively. On the other hand using bacterial additive in SBR the COD, BOD, and TSS tends to decrease by 97.9%, 98.0%, and 98.3%.
- Biological treatment in SBR tank is depending on bacterial additive which reduces the value of COD, BOD, and TSS because the leachate is consisting of aromatic organic components which are difficult to treat it by traditional methods, so using different types of bacteria is able to degrade these organic components.
- From the obtained results, it is concluded that it is necessary to use bacterial additive to leachate because bacterial additive remove the effect of TKN, and NH_3-N by 90.5, and 95.1 % respectively.

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