Effect of bacterial additives on the performance of septic tanks for wastewater treatment in the Upper Egypt rural area

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Abstract

A mixture of five selected, adapted, enzyme active producer bacterial species has been used as an additive to septic tanks in order to test its ability to increase treatment efficiency.

Regarding the septic tanks receiving waste with medium load, the maximum removal was achieved at day thirty and showed ranges for removal % reaching 91.3–94.4, 93–95.8, 90–91.7, 75–87, and 99.95–99.99 for COD, BOD_5, TSS, oil and grease and total coliforms, respectively. Septic tanks without bacterial additives were able to show removal % ranged as 79.3–88.5, 80–85.5, 75.1–83, 28–41.7 and 98.5–99.85 for the same parameters. Septic tanks that receiving influent with high load of pollutants, the maximum removal was achieved during the period of day 36–42 after addition of bacteria. The removal percentages for COD, BOD_5, TSS, oil and grease and total coliform were ranged as 93.8–97.2, 94.5–97.0, 94.0–97.9; 64.0–93.8; 99.81–99.99, respectively. Septic tanks without bacterial additives showed percentages of removal ranged as: 64.7–87.2, 73.4–89.6, 56.7–86.9, 34.6–45, and 92.8–99.28 for COD, BOD_5, TSS, oil and grease and total coliforms, respectively.
Keywords: wastewater treatment, Egyptian rural area, septic tanks, bacterial additives.

1 Introduction

Septic tanks/soil absorption systems are an option to consider wherever a centralized treatment system is not available. It has been the most popular on-site

www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SW100361

method [1]. The septic tank is an underground, watertight vessel installed to receive wastewater from the home. It is designed to allow the solids to settle out and separate from the liquid, to allow for limited digestion of organic matter, and to store the solids while the clarified liquid is passed on for further biological, physical and chemical reactions through the subsurface wastewater infiltrations system. Collected solids undergo some decay by anaerobic digestion in the tank bottom and depending on the activity of natural microorganisms that exist in the waste with minimal human intervention. Scum and grease float to the surface and the baffles keep it out of the soil absorption system. If an excessive amount of sludge is allowed to collect in the bottom of the septic tank, wastewater will not spend a sufficient time in the tank before flowing into the soil. Depending on the retention time of liquids in the septic tank, further biological treatment is expected from the natural microorganism existed.

Clarified septic tank effluent exits the septic tank and enters the soil absorption system where a biological biomat forms, contributing to even distribution of the waste into the soil [2]. The character of wastewater flowing into the soil absorption area is a critical variable for proper functioning of septic system. Soil absorption systems work most effectively when the influent does not contain significant levels of settleable solids, greases and fats. To avoid infiltration soil clogging by grease and scum, outlet baffles are suggested. Also, the use of two-compartment tanks recommended over single-compartment design. Absorption beds and trenches are the most common design options for soil absorption systems [1].

Since digestion of wastes in septic tanks is performed biologically, it is a temperature dependent process and colder temperature as well as the addition of toxic substances (as detergents, bleaching agents, acids, solvents, etc.) which may hinder the effective biological breakdown of wastes in septic tanks [3, 4] and cause septic tank upset. In addition, other cases such as when someone in the home is on chemotherapy for an extended period of time and the unused septic tanks for long period or the high loads of the hard biodegradable materials, may destroy or stress the biological activity in the septic tank. Under all these conditions, it is possible to suggest the addition of biological additives in the form of enzymes or microorganisms to help speed the re-establishment of biological activities.

Failure of systems to adequately treat wastewater may be related to inadequate site, inappropriate installation, or neglectful operation. Hydraulic overloading has been identified as a major cause of system failure [5].

Septic systems can act as sources of nitrogen, phosphorus, organic matter, and microbial pathogens, which can have potentially serious environmental and health impacts [6]. Since septic wastewater contains various nitrogen compounds Brown, installation of septic systems in areas that are densely developed can, in combination with other factors, result in the introduction of nitrogen contaminants into groundwater. Groundwater impacts can occur even when soil conditions are favorable because the unsaturated aerobic treatment zone located beneath the drain-field promotes conversion of wastewater-borne nitrogen to nitrates. If nitrate contamination of groundwater is a concern in the rejoin, control methods or denitrifying technologies may be required for safe operation of a septic system. Conventional septic systems are designed to operate indefinitely if properly maintained. However, because most household systems are not well maintained, the functioning life of septic systems is typically 20 years or less [8].

2 Materials and methods

2.1 Septic tanks

Septic tanks had been modified by some organizations as on-site, simple and low cost wastewater treatment system in a group of villages in Upper Egypt. The modified septic tank, as shown in Fig. 1, consists of the same main components of the traditional one and represented by:

a-entrance chamber b-sedimentation space
c-distribution chamber d-outlet chamber

There are anaerobic filter contained two layers of gravel. The bottom layer contained gravel (40–60 mm in diameter) of two third of the depth. The top layer contained gravel (20–40 mm in diameter). According to the design criteria, the retention time, is ranged as 1–3 days according to the tank type.

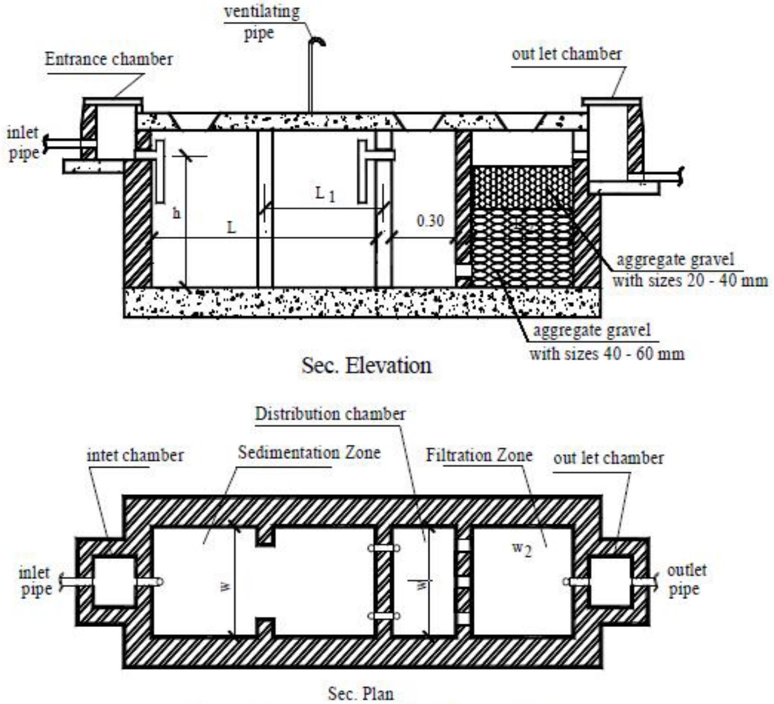

Figure 1: Typical modified septic tank.

The experimental work was executed on two types of modified septic tanks. The 1st type which receiving waste with medium organic load and serving 10 persons. The sedimentation chamber has the capacity of 2.4 m^3 (L= 2m, W = 1 m and D = 1.2 m), with retention time of 3 days. There was only one filter chamber with dimensions as, L 2 = 1 m, W = 1 m and D = 1 m. The 2nd type of septic tanks receiving wastes with high organic load and serving 200 persons (about 40 families). The sedimentation chamber with a capacity of 35.5 m^3, and has dimensions as L = 13 m, W= 1.7 m, and D = 1.8 m., with 2.2 days as retention time. There are two filter chambers each with dimensions of L = 1.5 m, W = 1.7 m and D = 1.2 m. The bacterial additives were added to the wastewater inside the distribution chamber and before the gravel filter as a ratio of the quantity of the wastewater found in the sedimentation chamber.

2.2 Bacterial cultures

From sewage samples collected from septic tanks, 800 bacterial isolates were isolated, purified by streaking on tryptic soy agar medium and microscopically examined to ensure its purity. All the isolates were assayed for their enzymatic activity using different substrates and focusing on: protease, amylase, lipase, esterase, cellulase, xylanase and urease production. Two hundred and forty isolates were selected according to their high enzyme production activity and only 158 of them that were able to show stability in activity through twenty times of sub-culturing. Adaptation program was carried out on those 158 isolates through testing their ability to produce the mentioned enzymes at different temperature and pH values. Only 78 isolates that was able to show the ability to produce enzymes at wide range of temperature (10–55°C) and pH values (4–10). Stability of the characters was tested by sequential culturing program using media containing sewage and finally only 23 isolates that could pass the screening tests. The Analytical Profile Index (API) identification system was followed and showed that the last 23 isolates could be grouped as belonging to 5 bacillus species. One strain of each species was selected, cultured on tryptic soy agar slants and kept in the refrigerator as stock culture to be used in the present study.

Two days before the experiment, the five strains were inoculated in nutrient broth and incubated at 37°C for 24 hr. The cultured strains were centrifuged at 4500 rpm for 10 min and the sediment from every 1 liter culture was collected separately in sterile bottle and kept in the refrigerator. The sediments were transported to the site of the experiment in icebox. Every septic tanks gravel filters were seeded with the culture sediments (the sediment resulted from 1 liter of culture/m^3 of tank capacity).

2.3 Sampling

Samples from the effluent from the septic tank under study before and after inoculation the mixture bacterial strains were collected in sterile glass bottles and transported in icebox to the laboratory for bacteriological and chemical examinations. The parameters were determined according to the Standard

Methods for the Examination of Water and Wastewater APHA [9], and included: total coliforms MPN/100, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS) and oil and grease.

3 Results and discussion

The application of bacteria for sewage treatment in septic tanks should ensure that it was conducted close to the recommendations prescribed by the U.S. Environmental Protection Agency [1, 8, 10] for minimizing the environmental and/or user risk. U.S. EPA standards ensure that the number of microorganisms emitted from the site where microorganisms are used is minimized. It does not specify specific limits for the emitted microorganisms. EPA specified that the introduced genetic material, in case of genetic engineered stains, must be limited in size to reduce the risk of introduction uncharacterized genetic material. In the present study, the used strains were selected from the natural habitat which have high rate of enzymatic activity as well as it can grew at wide range of pH and temperature and not genetically engineered strains.

Although direct monitoring data are unavailable, worst case do not suggest high levels of the public exposure resulting from the application of these bacteria in well designed and maintained septic tanks. However, human exposure via dermal and ingestion routes as well as release to the environment may occur if the effluent from the treated septic tanks is discharged on an open area or directly on surface water.

In the present study, the used strains were isolated from sewage and exist as common organisms in soil and ubiquitous nature. They are neither non-pathogenic nor toxigenic [11, 12]. For example, when *B. licheniformis* enter the human digestive system, it is not able to colonize to any large degree. However, if challenged by large numbers of this micro-organism, it may cause limited gastroentertities for only the compromised individuals [12]. Outside the gastrointestinal tract, it would likely be a temporary inhabitant of skin [13]. It is widely known as a contaminant of food, but not thought to be a causal agent for food poisoning [14]. There was no mention of any plant pathogenic activity [13].

The base considered in strains selection was to cover the various conditions at which the degradation of pollutants may occur (aerobically or anaerobically, and wide ranges of pH and temperature). The selected species of bacteria through their enzymatic activity can breakdown the different pollutants that usually occur in sewage such as carbohydrates, proteins, cellulose, urea, oil and grease (Table 1).

Three septic tanks located in villages namely Gragoos; Quina Governorate, El-Mahameid; Aswan Governorate, and Bany Sanad; Asuot Governorate were selected on the base that they receive wastewater influent with medium load of organics (COD 560–640 mg O_2/1 and BOD 350–400 mg O_2/1). A slight improvement in wastewater quality was achieved during the first few days after the addition the mixed culture of bacteria to the gravel filter. From day 6, the gradual increase in the percentages of removal in the examined parameters was observed reaching the maximum values at day 36 for the effluents of the three

Table 1: Characteristics of the selected strains used as septic tank additives.

Character	*Bacillus amylo-liquefaciens*	*Bacills licheniformis*	*Bacillus subtilis*	*Bacillus megaterium*	*Bacillus pumilus*
Growth	Facultative	Facultative	Aerobic	Aerobic	Aerobic
pH range	6-10	5-10	4-10	5-10	6-10
Temperature	10-50	10-55	10-50	4-45	10-50
Production of: Protease (break down of proteins)	++	++	++++	+++	+++
Amylase (break down of carbohydrates)	++	++	++++	+	+
Lipase (break down of grease)	++	++	++++	+++	+++
Esterase (break down of fats)	++	++	++++	+++	+++
Cellulase (break down of cellulose)	++	+	++++	+++	++++
Xylanase (break down of plant materials)	++	+	++++	+++	++++
Urease (break down of urea)	+++	++	++	++++	++

\+ Moderate ++ = Good +++ = Very Good ++++ = Excellent.

septic tanks. The maximum percentage of removal achieved was ranged as: 91.3–94.4 for COD, 93–95.8 for BOD, 90–91.7 for TSS, 75–87 for oil and grease, and 99.95–99.99 for total coliform. After 42 days a gradual decrease in percentages of removal for all determined parameters was observed, but still higher than the values achieved in the absence of bacterial additives.

At the end of the experimental period (60 days) the effluent of the septic tanks had the following character: COD; 77.2–104.8 mg O_2/l, BOD; 44.1–58.7mg O_2/l; TSS; 52.9–70.6 mg/l, Oil and Grease; 4.1–15 mg /l and total coliform 10^4–10^6 MPN/100 ml (Tables 2–4).

It is important to mention that septic tanks without bacterial additives showed removal percentages ranged as 79.3–88.5 for COD, 80–85.5 for BOD, 75.1–83 for TSS, oil and grease 28–41.7 for oil and grease, and 98.5–99.85 for total coliform (Tables 2–4).

Table 2: Changes in parameters rested after the addition of bacterial additives to septic tank at El Mahamid Village, Aswan Governorate.

parameters	Time in days after bacterial addition											
	0	3	6	12	18	24	30	36	42	48	54	60
COD inf.	560	565	568	578	585	605	615	620	635	640	650	655
COD eff.	116	113	98.3	87.9	76.6	70.2	60.9	54	62.2	71	91	104.8
% Removal	79.3	80.3	82.7	84.8	86.9	88.4	90.1	91.3	90.2	88.9	86.0	84.1
BOD inf.	400	405	418	428	435	450	470	465	440	435	430	425
BOD eff.	80	67.1	72.3	64.2	54.4	45.5	37.1	32.6	35.6	41.8	51.2	58.7
% Removal	80	81.2	82.7	85	87.5	89.9	92.1	93.0	91.9	90.4	88.1	86.2
Tss inf.	654	348	355	350	365	375	388	393	375	370	365	360
Tss eff.	88	85.6	78.8	65	58.4	50.3	42.3	39.3	41.3	44.8	49.6	52.9
%Removal	75	75.4	77.8	81.4	84	86.6	89.1	90.0	89.0	87.9	84.4	85.3
Oil & grease inf.	64	63	65	70	71	73	75	70	78	65	63	60
Oil & grease eff.	46	42.8	35.7	30.8	22.7	15.3	11.3	9.1	10.9	12.4	12.2	15
%Removal	28	32	45	56	68	79	85	87	84	81	79	75

Table 3: Changes in parameters rested after the addition of bacterial additives to septic tank at Benisand Village, Asuit Governorate.

parameters	Time in days after bacterial addition											
	0	3	6	12	18	24	30	36	42	48	54	60
COD inf.	600	610	625	635	660	690	700	710	735	715	710	720
COD eff.	87	86	81.3	73	64	56.6	50.4	47.6	52.2	60.8	65.3	79.2
% Removal	85.5	85.9	87	88.5	90.3	91.8	92.8	93.3	92.9	91.5	90.8	89.0
BOD inf.	350	353	358	360	365	368	375	388	390	385	383	380
BOD eff.	59.7	54	49.4	42.8	36.9	29.1	24	22	27.3	33.5	38.3	44.1
% Removal	84.1	84.7	86.2	88.1	89.9	92.1	93.6	94.3	93.0	91.3	90.0	88.4
Tss inf.	434	440	450	455	459	465	473	470	465	475	480	478
Tss eff.	73.8	73	69.3	63.7	56.9	50.7	44	39	41.1	47.5	52.3	66
%Removal	83	83.4	84.6	86.0	87.6	89.1	90.7	91.7	91.1	90.0	89.1	86.2
Oil & grease inf.	12.0	12.5	12.8	12.5	13.0	13.2	13.8	14.0	12.9	13	12.8	12.5
Oil & grease eff	8	8.1	7.54	6.34	5.5	4.5	3.6	3.5	3.47	3.73	3.84	4.1
%Removal	33.3	35.0	41.1	49.3	57.6	66.0	74.2	75.0	73.1	71.3	70.0	67.6

All parameters were determined as mg/l.

Table 4: Changes in parameters rested after the addition of bacterial additives to septic tank at Garagoos Village, Quina Governorate.

parameters	Time in days after bacteria addition											
	0	3	6	12	18	24	30	36	42	48	54	60
COD inf.	640	635	655	670	678	690	710	715	720	705	712	720
COD eff.	96	90.8	81.9	72.4	62.4	53	46.2	40	49	55.7	69.8	85.4
% Removal	85	85.7	87.5	89.2	90.8	92.3	93.5	94.4	93.2	92.1	90.2	88
BOD inf.	400	408	418	435	450	468	477	489	494	490	480	492
BOD eff.	58	57.5	53.5	47.9	41.9	35.1	27.2	20.5	24.7	32.8	41.8	54
% Removal	85.5	85.9	87.2	89	90.7	92.5	94.3	95.8	95.0	93.3	91.3	91.3
Tss inf.	380	388	395	398	415	420	428	435	430	428	420	415
Tss eff.	69.2	68.7	64.8	59.7	56.9	51.7	46.6	42.6	48.2	52.6	59.2	70.6
%Removal	81.8	82.3	83.6	85	86.3	87.7	89.1	90.2	88.8	87.7	85.9	93
Oil & grease inf.	12	11.8	12.5	12.8	13.3	13.7	13.9	14.2	14	12.9	13.2	13.0
Oil & grease eff.	7	6.7	6.5	5.8	5.2	4.5	3.6	2.94	3.3	3.4	4	4.3
%Removal	41.7	43.2	48	54.5	60.9	67.5	74.3	79.3	76.5	73.8	69.8	67.1

Other three septic tanks were selected in three villages, namely Enibis; Souhag governorate, Bani Sanad; Asuot governorate, and El-Mahameid; Aswan governorate to represent tanks receiving influent with high load of pollutants (COD; 1072–2180 mg O_2 /l and BOD; 714–1200 mg O_2 /l, TSS 205–1144 mg/l, oil and grease 40–104 mg/l al total coliform 10^8 –10^9 MPN/ 100 ml. Again the actual improvement in the effluent quality appeared at the 6th day after bacterial addition to the tanks. Microorganisms used for wastewater treatment are likely to be exposed to a wide variety of environmental stresses. Microorganisms must adapt to these conditions to be able to degrade the pollutants. In some cases genetic engineering may be helpful in augmenting resistance to such stress, thereby facilitating good performance of degradative organism under adverse conditions (Clark [15]).

In the present study, the maximum removal efficiency appeared after 42 days and may extend to 48 days. During this period, the removal percentages for COD, BOD, TSS, oil and grease and total coliform were ranged as 93.8–97.2, 94.5–97.0, 94.0–97.9; 64.0–93.8, 99.81–99.99, respectively (Tables 5–7).

Septic tanks without bacterial additives showed removal efficiency (as %) ranged as 64.7–87.2, 73.4–89.6, 56.7–86.9, 34.6–45, and 92.8–99.28 for COD, BOD, TSS, oil and grease and total coliform, respectively.

Table 5: Changes in parameters rested after the addition of bacterial additives to septic tank at El Mahamid Village, Aswan Governorate.

parameters	Time in days after bacteria addition											
	0	3	6	12	18	24	30	36	42	48	54	60
COD inf.	2180	2210	2230	2260	2290	2280	2310	2340	2380	2350	2280	2220
COD eff.	280	2785	245.5	214.7	176.3	139.1	101.6	74.9	66.6	82.3	114	162.1
% removal	87.2	87.4	89.0	90.5	92.3	93.9	95.6	96.8	97.2	96.5	95.0	92.7
BOD inf.	1200	1190	1230	1250	1280	1290	1295	1310	1330	1360	1290	1300
BOD eff.	125	120.2	114.4	100	88.3	72.2	58.3	45.9	39.9	55.8	77.4	102.7
% removal	89.6	89.9	90.7	92.0	93.1	94.4	95.5	96.5	97.0	95.9	94.0	92.1
Tss inf.	1144	1160	1180	1210	1225	1250	1270	1290	1310	1325	1320	1310
Tss eff.	150	148.5	139.2	127	111.5	98.8	81.3	67.1	61.6	79.5	100.3	115.3
%removal	86.9	87.2	88.2	89.5	90.9	92.1	93.6	94.8	95.3	94.0	92.4	91.2
Oil & grease inf.	104	106	109	112	115	120	123	108	118	120	117	115
Oil & grease eff.	68	67.8	65.7	61.9	58.4	55	48.8	37.4	40.5	43.2	44.7	46
%removal	34.6	36	39.7	44.7	49.2	54.2	60.3	65.4	65.7	64	61.8	60

Table 6: Changes in parameters rested after the addition of bacterial additives to septic tank at Anebas Village, Sohag Governorate.

parameters	Time in days after bacteria addition											
	0	3	6	12	18	24	30	36	42	48	54	60
COD inf.	1072	1082	1120	1070	1090	1115	1135	1100	1150	1125	1110	1100
COD eff.	234	233.7	224	181.9	157	127.1	96.5	62.7	51.8	58.5	81	99
% removal	78.2	78.4	80	83	85.6	88.6	91.5	94.3	95.5	94.8	92.7	91.0
BOD inf.	714	720	730	755	770	790	805	820	810	825	800	790
BOD eff.	142.1	140.4	126.3	111.7	93.2	75.8	55.5	36.1	34	41.3	52.8	53.7
%Removal	80.1	80.5	82.7	85.2	87.9	90.4	93.1	95.6	95.8	95.0	93.4	92.2
Tss inf.	852	850	870	887	900	920	938	960	985	970	930	900
Tss eff.	160	158.1	147.9	131.3	112.5	93.8	72.2	56.6	50.2	58.2	67	82.8
%Removal	81.2	81.4	83	85.2	87.5	89.8	92.3	94.1	94.9	94.0	92.8	90.8
Oil & grease inf.	40	40.1	40.3	40.8	41.0	41.7	42.3	43	72.7	42	41.8	41.0
Oil & grease eff.	22	21.5	20.2	17.95	15.79	13.43	11	8.6	8.33	8.44	9.4	10.25
%Removal	45	46.5	50	56	61.5	67.8	74	80	80.5	79.9	77.5	75

4 Conclusions

Although, the removal efficiency of septic tanks with bacterial additives was higher in case of those receiving the high load of pollutants in the influent than in those receiving medium load, the pollutants residual in the final effluent (after 60 days) of the first case are higher (Tables 2–7). The further decrease in the total coliform density resulted after using bacterial additives may be due to the possibility of antimicrobial agent production. For example, *B. licheniformis* is capable of producing several antimicrobial agents such as licheniformin [16], bacitracin [17] and others. In addition, metabolite(s) produced by *B. licheniformis* and *B. amyloliquefaciens* showed antifungal activity [18–20].

Table 7: Changes in parameters rested after the addition of bacterial additives to septic tank at Benisand Village, Asuit Governorate.

parameters	Time in days after bacteria addition											
	0	3	6	12	18	24	30	36	42	48	54	60
COD inf.	1360	1330	1410	1280	1330	1400	1390	1360	1425	1370	1350	1340
COD eff.	480	463	481	339	279.3	217	132	84	74	82.2	95.85	124.6
% Removal	64.7	65.2	68	73.5	79	84.5	90.5	93.8	94.8	94.0	92.9	90.7
BOD inf.	980	950	1030	920	950	1000	990	1055	1020	980	980	960
BOD eff.	260	247	226.6	165.6	147.3	120	84.2	58	49	49	93.7	74.9
% Removal	73.4	74	78	82	84.5	88	91.5	94.5	95.2	95	93.5	92.2
Tss inf.	2051	1980	2100	1880	1970	2050	2040	2000	2250	2150	2000	2000
Tss eff.	888	817.74	798	573.4	457	329	177.5	60	47.25	47.3	96	124
%Removal	56.7	58.7	62	69.5	76.8	84	91.3	97	97.9	97.8	95.2	93.8
Oil & grease inf.	3.4	3.3	3.8	3.1	3.9	3.5	3.7	3.2	3.9	3.6	3.6	3.4
Oil & grease eff.	2	1.8	1.92	1.3	1.29	0.84	0.56	0.2	0.22	0.22	0.27	0.28
%Removal	41.1	45.5	49.5	58.0	66.8	76.1	85.0	97.8	94.4	93.9	92.6	91.8

From the results, it seemed that septic tanks need to be reinoculated with the selected strains after 30–45 days. Cells inoculated in the gravel filter start to reproduce firm biofilm on gravel surfaces as well as on the tank walls. The decrease in bacterial activities and pollutants removal efficiency may be due to one or more of the following reasons. The first is the presence of toxic materials in the wastewater which can inhibit the survival of the community. The second, is that such chemicals may produced and biochemically incompatible with the effective catabolism of the target compound and may poison the process. The third reason is the interactions between microorganisms such as the lytic activity of amoebicin m-4-A that produced by *B. licheniformis* against *B. megaterium* [21]. The forth possibility is that biofilm formed may slough out and lost by the time with the effluent. The use of other material than gravel which have rough surface may be much more helpful.

Concerning the use of cultured bacteria as additives to septic tanks in order to provide the system with types of bacteria at density necessary to improve and enhance system function, there are two approaches. The first say that because of the presence of significant numbers and types of bacteria, enzymes, yeasts, and fungi in typical residential and commercial wastewaters, the use of septic system additives containing these or any other ingredients is not recommended [10]. The second approach recommended the use of bacterial additives for septic tanks under normal as well as adverse conditions.

The use of selected and adapted natural bacteria as additive have the same advantage as the home field ones and the competition with the native bacteria of the system won't exist. These bacteria can reduce retained organic molecules to soluble compounds and gases. This digestion can significantly further reduce sludge volume especially in warm climate of the Upper Egypt. Material degraded by bacteria does not contribute in increasing the loading of BOD, TSS.

Users must be aware that when the application of bacterial additives is not the solution for all symptoms of septic tank failures the cause of failure should be identified and appropriate corrective action taken to prevent recurrences.

Finally, in any case, bacterial additives are not an alternative to proper maintenance and do not eliminate the need for routine pumping for a septic tank.

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