Improving Septic Tank Treatment Efficiency Through Simple Design Modifications

Hegazy*, A.M.F., Nabil, R.E

Associate Professor of Sanitary Engineering, Higher Technological Institute, 10th of Ramadan City, Egypt
Assistant Professor of Environmental Engineering, German University in Cairo (GUC), New Cairo, Egypt

ABSTRACT
A septic system is a highly efficient, self-contained, underground wastewater treatment system. The simplicity of its operation and the low cost of construction and the ease of maintenance raise the depending on the septic tanks in rural areas. But its low efficiency was the main difficulty against the environmental aspects that raise the needs for simple modifications that increase the removal efficiency without complication of its construction or operation. Several trials had been made for this modification but most affects its simplicity & cost.

This study used simple modified septic tank divided to three compartments one for settling, second for submerged bio gravel filter & third for upflow bio plastic filter.

From three months operation for domestic sewage The study resulted the suitability of the modification to improve the removal efficiency of the septic tank from 50% for BOD & 60% for TSS to become 83.66% for BOD & 86.91% for TSS which are promising removal efficiencies for such simple system that raise the possibility to depend on it as one of the low cost treatment procedures for sewage treatment in rural areas.

KEYWORDS: Rural Sanitation, Sewage treatment, septic tank, modifications of septic tank.

INTRODUCTION
Septic tanks are most appropriate in low- to medium-density urban areas. Septic tanks with on-site disposal of their effluent or off-site disposal by settled sewerage are normally less expensive than conventional sewage. So serving middle and upper income areas with septic tanks leaves (or should leave) more resources available to serve low-income areas.

A septic system is a highly efficient, self-contained, underground wastewater treatment system. Because septic systems treat and dispose of household wastewater onsite, they are often more economical than centralized sewer systems in rural areas where lot sizes are larger and houses are spaced widely apart. Septic systems are also simple in design, which make them generally less expensive to install and maintain. And by using natural processes to treat the wastewater onsite, usually in a homeowner's backyard, septic systems don't require the installation of miles of sewer lines, making them less disruptive to the environment [1].

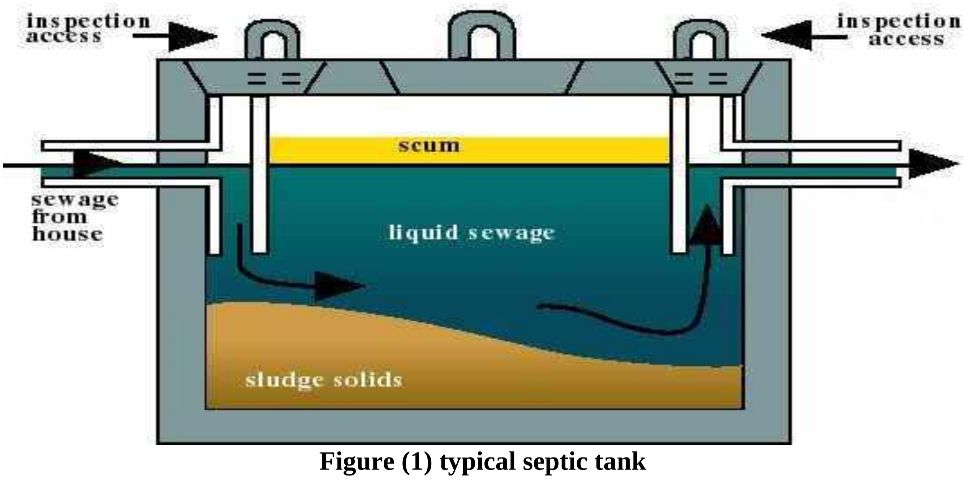

Figure (1) typical septic tank

Septic tanks are small rectangular chambers, usually sited just below ground level. In which household wastewater is retained for 1-3 days. Most commonly they are constructed in brickwork or block work and rendered internally with cement mortar to ensure water tightness [2].

A septic tank generally consists of a concrete or plastic tank (or sometimes more than one tank) of between 4000 and 7500 liters (1,000 and 2,000 gallons) connected to an inlet wastewater pipe at one end and a septic drain field at the other. In general, these pipe connections are made via a T pipe, which allows liquid to enter and exit without disturbing any crust on the surface. Today, the design of the tank usually incorporates two chambers (each equipped with a manhole cover), which are separated by means of a dividing wall that has openings located about midway between the floor and roof of the tank [3].

The purpose of the septic tank is to provide an environment for the first stage of treatment in onsite and decentralized wastewater systems by promoting physical settling, flotation, and the anaerobic digestion of sewage. Additionally, the tank allows storage of both digested and undigested solids until they are removed [4].

Septic tank solids include both biodegradable and non-biodegradable materials; although many of the solids will decompose, some solids will accumulate in the tank. Anaerobic and facultative biological processes in the oxygen-deficient environment of the tank provide partial digestion of some of the wastewater components. These processes are slow, incomplete, and odor producing. Gases (hydrogen sulfide, methane, carbon dioxide, and others) result from the anaerobic digestion in the tank and may create safety hazards for improperly equipped service personnel [9]. Most of septic tanks achieves removal efficiency for BOD between 35 -50% and about 60% for TSS [4].

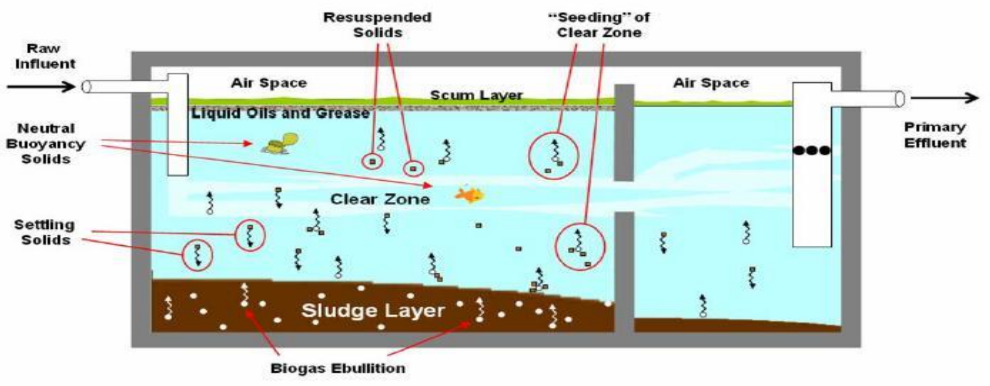

Figure (2) biological action In typical septic Tank

Modifications of Septic Tank

The simplicity of its operation and the low cost of construction and the ease of maintenance raise the depending on the septic tanks in rural areas. But its low efficiency was the main difficulty against the environmental aspects that raise the needs for simple modifications that increase the removal efficiency without complication of its construction or operation.

There are many septic tanks had simple modifications which were introduced into a conventional septic tank by building cross walls in order to improve its performance or filled the tank with crashed bricks to breakdown the soluble part of the influent BOD, The following applications describe the most popular applications of modified septic tank in world and Egypt.

In the south east of Asia septic tank was used with bamboo stalk as biological filter behind the tank increased the efficiency to 75 % [5].

In the thirtieth septic tank was used with two rooms in El Fayom villages by the government to raise the efficiency from 40% to 50% [6].

In the fiftieth and the beginning of the sixtieth septic tank was used with three rooms in El Tahrer administration and some areas of the new valley by the ministry of lands reclamation and the high dam to raise the efficiency to 55 % [6].

Septic tank followed by submerged gravel filter applied in three villages in Fayoum governorate by eng. Ebaid Fahiem through Care project for sanitation raised the efficiency to 70 % [7].

Septic Tank followed by gravity sand filter applied in El Kelh El Baharyia village in Edfo, Aswan made by El Nadi, M. H. for SFD project and raised the efficiency to 75 % [8].

Septic Tank followed by gravel filter then gravity sand filter applied in Fayoum & Beni Sweif by Galal, A. S. in five villages for Care project for sanitation in rural areas and raised the efficiency to 75-80% [9].

Two chambers Septic Tank followed by upflow gravel filter by El Nadi, M. H. in two villages in Qena for SFD project raised the efficiency to 70 % [10].

Septic Tank followed by sand filter then cool filter by El Nadi, M. H., for SFD project in Sohag & Qena and aised the efficiency to 77-82% [11].

In the ninetieth and the beginning of the twenty one century septic tank was used with assistant rooms containing unsubmerged gravel (aerobic reaction) behind the tank increased the efficiency of tank to 75% in Sohag and Asuit villages at years 1995-2003. [6].

Using the unsubmerged plastic media (aerobic reaction) by el Nadi, M. H. behind the tank increased the efficiency of it to 80% in Aswan villages at year 2000 [12].

Using the gravel then crushed stone then sand as a physical filter behind the tank increased the efficiency to 75% in Aswan and Edfo villages at year 1999 [13]

Upflow Septic tank compartment and anaerobic Baffled Reactor compartment (USBR) was developed as described in figure (3) and tested at pilot scale for 6 months at Iowa State University by Dr. T. Sabry and Dr. S. Sung [14] and for one year at Oseem village, Giza then a full-scale system was constructed in Abo-Khalifa village in El Tel El Keeber district, Ismailia governorate. During almost one year of continuous operation and monitoring, the average results were 84% for the COD removal, 81% for the BOD removal, and 89% for the TSS removal [14].

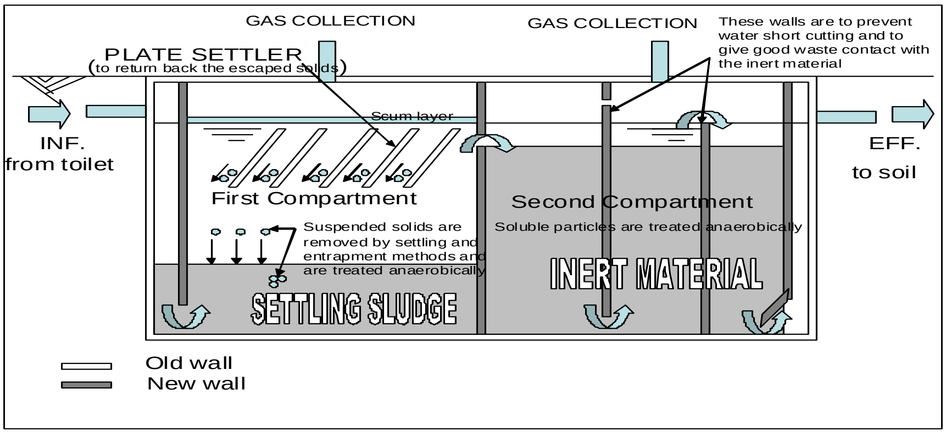

Figure (3) modified septic tank USBR

Even the USBR unit achieved high removal efficiency than the other modifications [15], but it increases the construction and operation costs and increases also the operation difficulty this raised the need to go to simplified modification as illustrated here after.

MATERIALS & METHODS

Our study applied on a septic tank erected in Nawa Village Qalubiya Governorate, Egypt, that served 10 houses with volume 10m3 enough for 2 days retention time divided by two plastic sheets partitions to three compartments as illustrated in figure (4). These compartments are as follows:-

1. Settling zone with volume 5m3
2. Submerged down flow gravel zone with volume 2.5 m3 (contains 1m3 gravel above a reinforcement plastic mesh)
3. Upflow plastic particles filter zone with volume 2.5 m3 (contains 0.7 m3 plastic particles between 2 plastic mesh).

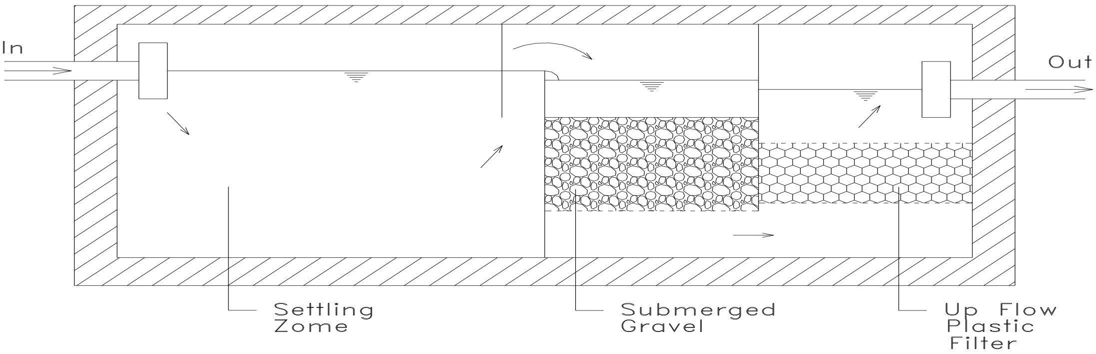

Figure (4) Applied modified septic tank

The work was done on three months from March to May 2015 with variable climatic conditions as illustrated here after. The measurements were done for four samples; first from tank inflow, sample after settling zone, sample after submerged gravel and outflow sample to measure both BOD & TSS according to American Standard Methods [16], to evaluate the unit efficiency. The measurements made in 3 days /week for the whole period. And a start up period for 10 days was made before collecting data.

RESULTS & DISCUSSIONS

Table (1) shows the average of three readings weekly measured parameters during the study period for the climatic temperature and for the influent and the effluent of each step in the unit to illustrate the efficiency of such system.

Table (1) The weekly average results during the study period

Month	week	Temp. °C	inflow		Settling Eff.		Submerged Gravel Eff.		Effluent	
			BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
March	1	18	564	570	338	171	169	188	93	75
	2	20	555	566	332	170	166	187	91	74
	3	20	540	556	324	166	162	183	89	74
	4	22	521	543	312	163	158	180	87	72
April	1	17	525	540	315	162	158	178	87	71
	2	23	507	534	304	160	152	176	84	70
	3	29	500	533	300	160	150	177	83	71
	4	42	466	490	280	147	140	162	77	65
May	1	38	480	499	278	145	139	160	76	64
	2	33	473	498	274	145	137	160	75	64
	3	32	477	497	276	144	138	160	76	64
	4	35	481	499	279	145	140	160	77	64
Average		27.4	507.4	527.1	301	156.5	150.8	172.6	82.9	69

From table (1) it can be seen that the average removal efficiency for BOD was about 83.66% and for TSS was about 86.91% which are more than all the other modifications had achieved [8] & [13]. Even the produced BOD & TSS still out of the permissible limits for draining to the agricultural drain, but the results show good removal efficiency for both BOD & TSS can be promise with medium and low strength sewage of BOD $\leq$ 300ppm & TSS $\leq$ 450 ppm to became the suitable treatment that achieves the law limits for disposing into agricultural drains.
The settling zone worked as a septic tank with one day retention time & removes in average between 40-45% of BOD & 68-72% of TSS. Under condition of sludge dewatering every 2-3 months to prevent its flotation with the anaerobic action produced gases.

The submerged gravel media worked as anaerobic biofilter that removed about 46-50% of BOD but in the other hand it caused the increase of TSS by about 10-14 % than the effluent of settling zone.

The upflow plastic particles media achieved as anaerobic biofilter and as physical filter media removal efficiency 40-45% for BOD & 55-60% for TSS. This was for low strength of its influent compared with the submerged gravel media zone.

The total removal efficiency for the proposed unit were varied between 82-85% for BOD & 85-89% for TSS during the all readings with almost stability of the removal efficiency and the system success that make this modification achieved a very stable, costly economic and easy treatment procedure to deal with rural area sanitation.

CONCLUSIONS

The study could be concluded the following items:

1. The suitability of applying the septic tank followed by submerged gravel biofilter followed by upflow plastic particles biofilter to improve the removal efficiency of the septic tank from 50% for BOD & 60% for TSS to became 83.66% for BOD & 86.91% for TSS which are promising removal efficiencies for such simple system that raise the possibility to depend on it as one of the low cost treatment procedures for sewage treatment in rural areas.
2. The system stability and easy operation and maintenance needs raise the possibility of its application in future.
3. The system suitability for low & medium strength sewage and the possibility of application with high strength sewage with the use of influent dilution water.
4. The additional studies for improving the system efficiency is needed to handle the high sewage strength in rural areas due to low water consumption and drainage of manure in the sewerage system.

REFERENCES

[1] Harris, B.L., Hoffman, D.W. & Mazac Jnr, F.J. , “Reducing Contamination by Improving Household Wastewater Treatment” Black land Research,Centre Water Sciences Laboratory, (updated 15 Aug 2001, accessed 27 Aug 2002)

[2] Switzenbaum, M. S. and Grady, C. P. L., Jr., “Anaerobic treatment of domestic wastewater” J. Water Pollution Control Federation, 58 (2): 102-106,(1986)

[3] Metcalf & Eddy Inc., “Wastewater Engineering: Treatment and Reuse”, 4th edition, (2003)

[4] R. Dodge Woodson, “Water wells and septic systems”, handbook, McGraw-Hill, USA, (1999)

[5] El Gohary, F.A.; Abou El-Ela, S.I.; El-Hawary, S.; El-Kamah, H.M. and Ibrahim, H, “Evaluation of wastewater treatment technologies for rural Egypt”, Intern. J. Environmental Studies, vol. 54, pp.35-55, (1998)

[6] Osman, M., “Application of upflow septic tank/baffled reactor for sewage treatment in rural Egypt”. M.Sc. thesis, Civil Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt, (2008)

[7] El Nadi, M.H., Ulaa, G.H.,” Annual Evaluation report of Cafee project”, funded by Danida and operated by Care international Organization (1997).

[8] El Gohary, F.A, “Improve the performance of the primary treatment”, Proceedings of the Improve the self purification performance in the open agricultural drain conference, Cairo, Egypt, (2003)

[9] El Nadi, M.H., Ulaa, G.H., “Mid Term Evaluation report of Cafee II project”, funded by Danida and operated by Care international Organization (2002).

[10] El Sergany, F.A. “WEG Evaluation Consulting report” for SFD project in Edfo Villages, (2004).

[11] El Nadi, M.H. “WEG Study Consulting report” for SFD project in Qena Villages, (2005).

[12] El Sergany, F.A. “WEG Technical Consulting report” for SFD project in Aswan Villages, (2000).

[13] El Sergany, F.A. & El Nadi, M.H., “Rural Sanitation consulting study” for SFD project in Aswan Governorate, (2004).

[14] Sabry, T.I.M. and Sung, S., “The Feasibility of Using an Anaerobic Modified Septic Tank in the Developing Countries”, World Water Congress and Exhibition, IWA, Marrakech, Morocco, 19– 24 September (2004)

[15] Sabry, T.I.M. and El Gendy, A. Sh., “The Use of USBR in Domestic Wastewater Treatment in Rural Areas”, Ain Shams Univ., Faculty of Eng., 2nd Intr. Conf. for Environmental Engineering, Cairo, Egypt, April (2007).