Impacts of Biological Additives, Part 2: Septic Tank Effluent Quality and Overall Additive Efficacy

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Abstract **The efficacy of 1,200+ septic tank additives on the market has always been a concern due to the previous lack of independent, replicated, third-party, field-scale research studies. Twenty experimental units (well-maintained, full-size, functioning septic tanks) were pumped out 2–3 years before being assessed in the study presented here. These units were treated with one of three biological additives or a control in a double-blind study. Effluent data analyzed using a mixed linear model showed that the overall treatment effect was significant for effluent five-day biochemical oxygen demand (BOD_5) concentrations. One additive had significantly lower effluent BOD_5 concentrations in septic tank effluent than the control and the other two additives had the same BOD_5 as the control. No statistically significant effluent total suspended solids concentration effect occurred for any additive. These results were also considered in concert with two prior related studies regarding microbiological contents as well as sludge and scum accumulation rates across three prior-maintenance levels in 48 septic tanks.**

Introduction

People living in subdivisions, rural areas, and other suburban areas depend upon individual onsite wastewater treatment systems for household wastewater treatment. The number of onsite wastewater treatment system users increases every year due to land development resulting from increasing rural populations, continuous urban sprawl, and cost efficiency.

The increasing popularity of onsite wastewater treatment systems has led to widespread production and use of septic system additives. More than 1,200 septic system additives are available on the market (National Small Flows Clearinghouse, 2002).

Unfortunately, very little peer-reviewed, published, and replicated field research exists regarding the efficacy of biological septic tank additives. Additive effectiveness assessments have, up until now, typically relied on laboratory or benchtop studies (Jantrania, Sack, & Erap, 1994), or on literature and process assessments (Scow, 1994), often by product manufacturers, which have not been substantiated in the field via independent, third-party, replicated experiments. Pradhan and co-authors (2008, 2011), however, recently reported results of comprehensive, replicated field experiments using 48 full-scale septic tanks as the experimental units. Those studies included statistical evaluation of additive impacts on total microbial concentrations as well as digestion of sludge and scum. Those studies were conducted across a comprehensive cross section of septic tanks including three prior-maintenance levels (i.e., well-maintained tanks, pumped 2–3 years prior to study; poorly maintained tanks, not pumped within 15–20 years prior to study; and an intermediate prior-maintenance level, with a pumping schedule between the two extremes).

A benchtop study using scaled-down tanks conducted by Jantrania and co-authors (1994) revealed that under stress conditions sludge accumulation rates were significantly different in additive-treated tanks than in control tanks. Microbial conditions within laboratory benchtop anaerobic reactors, however, may not be fully representative of the more diverse biological conditions (e.g., including larger and more complex biological organisms) that occur within full-scale systems serving individual residences. In addition, laboratory-scale benchtop reactors do not represent the variability in total daily flow, flow regime, and solid addition patterns throughout the day or variability in biochemical oxygen demand (BOD), organisms, and food additions that occur from one septic tank to another. These variations often result due to differences from home to home in how families use water and dispose of waste solids as well as in various wastewaters generated.

A recent study by Pradhan and co-authors (2008) found no significant impacts of three additives on total bacterial concentrations in septic tanks. Additionally, no generally positive additive effects (for additives as a generic group) on sludge and scum decomposition were observed by Pradhan and co-authors (2011) across a range of septic tank maintenance levels. Positive impacts (reductions in sludge accumulation rate) for two out of the three additives evaluated, however, were observed under a specific set of conditions. Those reductions in sludge accumulation rates (i.e., sludge depth continued to increase for the treatment, however, at a slower rate than for the control) only occurred within highly maintained septic tanks. While those findings were potentially positive, they also led to a concern about whether reductions in accumulated sludge were truly a positive benefit of these additives. If sludge reduction also was associated with increased five-day BOD (BOD_5) or total suspended solids (TSS) concentrations in the septic tank effluent being delivered to the drain field, then sludge reductions due to additives in the tank would be a net negative effect, rather than a positive impact.

BOD and TSS contents are common indicators of wastewater strength. These two wastewater parameters have been of great interest to onsite wastewater researchers because of their impacts on biological clogging mat (biomat) formation within drain field trenches. Biomat formation is accelerated by disposal of effluent with higher concentrations of organic material as estimated by BOD_5 (Laak, 1970; Siegrist, 1987). Excessive biomat formation in the drain field due to increased BOD_5 and TSS in septic tank effluent could reduce sewage effluent infiltration rates into the soil significantly. Hence, increased wastewater strength can cause premature hydraulic failures of on-site systems (Brown, 2006; Siegrist & Boyle, 1987; Tyler & Converse, 1994). In other words, an important question resulting from the work of Pradhan and co-authors (2011) is whether reductions in sludge accumulation rates in well-maintained tanks were counteracted by increased contaminant emissions from the septic tanks to the associated drain fields.

Therefore, one goal of the research described here was to focus exclusively on the high-maintenance septic tanks from prior studies by Pradhan and co-authors (2008, 2011). Specifically, our study objective was to measure the impacts of biological additives on BOD_5 and TSS effluent concentrations emitted by recently pumped septic tanks. Significantly higher wastewater strength from additive-treated tanks compared to control tanks could indicate a propensity for causing excessive biomat formation. If so, this would have a negative overall impact regardless of any potential reduction in sludge accumulation rates within septic tanks themselves. By contrast, if selected additives enhance digestion while not increasing effluent BOD_5 or TSS concentrations, then these additives would be expected to have a positive impact overall on performance of regularly pumped septic systems.

A second research goal of this article was to provide a value assessment of combined impacts from our study and those by Pradhan and co-authors (2008, 2011) regarding biological septic tank additives. Note that ours is a field-based, independent, third-party, statistically designed, and replicated experimental study using full-scale septic tanks and the only known study of its kind in the U.S. Additive manufacturers or distributors provided no research funding for this study and were not involved in the research. The additive products tested were purchased directly from commercial retail stores.

Materials and Methods

Twenty full-scale, functioning septic tanks serving residences at a mobile home park located in Orange County, North Carolina, were used for our study. The septic tanks studied here represented highly maintained tanks in that all 20 tanks were pumped 2–3 years prior to the start of the study and had minimal initial amounts of accumulated solids (sludge and scum) prior to the experiment. The experimental units were two-compartment septic tanks with outlet tees and straight pipe inlets. None of the septic tanks were fitted with effluent filters. Three liquid biological additives used in the study came from local retail stores: Drano septic tank additive (additive 1), Liquid Plumr septic tank additive (additive 2), and Rid-X septic tank additive (additive 3).

Distribution of the additive application treatments followed a double-blind approach. Blocks were established on the basis of similar initial solid levels (sludge and scum). The three additives and the control were randomly assigned at the start of the experiment to the four experimental units within each of the five blocks by secondary researchers. The secondary researchers applied the additives each month (every four weeks) and the primary researchers made the field measurements, collected samples, and analyzed the data. The septic tank additives were added directly to the inlet of all septic tanks following timing and volume suggested by additive manufacturers. Viable microbial populations in each container were enumerated before their application to the tanks. Monthly analysis revealed that all additives contained substantial numbers of viable microbes when they were added to the septic tanks (Pradhan et al., 2008).

Septic tank effluent grab samples were collected every four weeks after initiation of additives from within the outlet sanitary tee using a weighted sampling head and a handheld vacuum pump (Clark, 1999). The first sample was collected in February. The sampling head was held approximately 5.7 cm below the surface of the effluent within the outlet sanitary tee as the sample was obtained. Samples were handled, transported, and stored following standard procedures. TSS and BOD were analyzed following *Standard Methods for the Examination of Water and Wastewater* (Clesceri, Greenberg, & Trussell, 1989).

The TSS and BOD_5 data were analyzed statistically using the linear mixed model implemented with the MIXED procedure (Littel, Henry, & Ammerman, 1998) in the SAS System to determine if the additives had impacts on the quality of effluent leaving the septic tanks. This statistical model is advanced compared to that used earlier by Clark (1999). For instance, Clark only assessed additives as a combined group, whereas our study considers Dunnett's *t*-tests ($\alpha = .05$) performed on the least squares means (LSM) TSS and BOD_5 to evaluate specific treatment effects over control and adjusted *p*-values were used for smallest family-wise significance level comparison. The model used for our study was as follows.

Y = treatment + time + time*treatment + within-tank error.

Results and Discussion

Effluent Quality

BOD_5

Average BOD_5 concentrations in effluent from septic tanks not equipped with effluent filters (Figure 1) were within normal ranges (150–250 mg/L) suggested by Crites and Tchobanoglous (1998). Septic tank effluent data showed that control tanks had the highest average BOD_5 concentration (LSM = 251.9 mg/L; *SE* = 39.21) followed by additive 3 (LSM = 225.6 mg/L; *SE* = 39.09), additive 1 (LSM = 210.9 mg/L; *SE* = 39.09), and additive 2 (LSM = 184.1 mg/L; *SE* = 39.09).

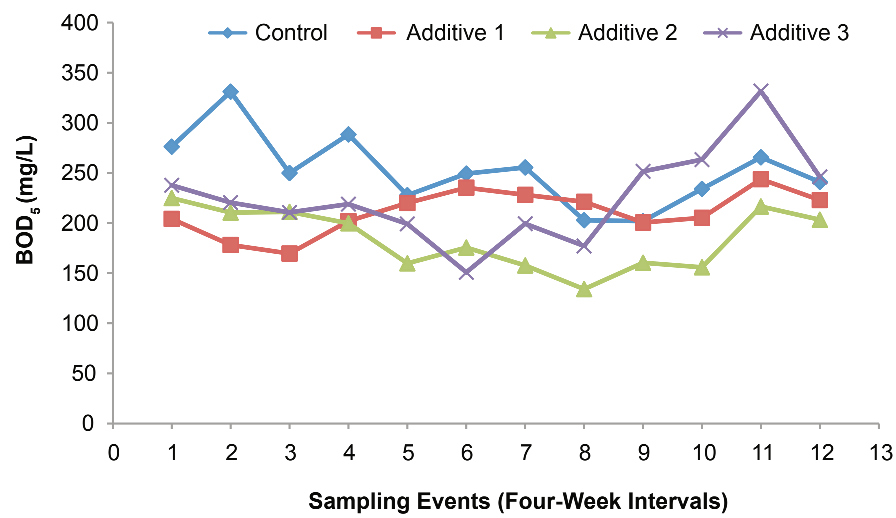
Tanks treated with additive 2 consistently maintained lower effluent BOD_5 concentrations than the control (Figure 1). Such long-term additive effects were not observed for tanks treated with additive 1 and additive 3. Effluent BOD_5 concentrations in tanks treated with additive 1 and additive 3 were lower than control tanks until the eighth and ninth sampling events (from February to late August) when the concentrations exceeded control levels. This short-term transitory effect might be due to a number of causes; for example, it may be due to changes in influent strength as well as inefficiency of additives. Alternatively, larger and more complex biological organisms may affect BOD_5 consumption and degradation within a septic tank. The actual causes are unknown in this study, however.

The overall additive treatment effect on BOD_5 was significant based on a two-way analysis of variance (ANOVA) at $\alpha = .05$ (Table 1). Statistical significance of the treatment effect indicates that the BOD_5 concentrations observed during the study were affected by the use of septic tank additives. Additive BOD_5 contents averaged 10% to 27% less than the control, depending on the additive. The potentially significant impacts of specific additives on effluent BOD_5 concentrations were evaluated by Dunnett's *t*-test at an $\alpha = .05$ level. These data indicated that effluent BOD_5 concentrations for additive 2 tanks (adjusted $p = .0131$; $SE = 23.71$) were significantly lower than the control. Effluent BOD_5 differences between the control and additive 1 (adjusted $p = .2031$; $SE = 23.71$) and between the control and additive 3 (adjusted $p = .5443$; $SE = 23.71$), however, were not large enough to be statistically significant.

A significant overall time effect also occurred although the treatment and time interaction was not significant for BOD_5 (Table 1). While the time effect was significant, it was not consistently expressed across all treatments and control (Figure 1). In general, however, effluent BOD_5 concentrations were reduced in summer or early fall compared to spring or winter. This time effect may relate to life-cycle impacts of larger biological organisms periodically observed within the septic tank (e.g., roaches, filter flies, etc.); however, the possible cause of the time effect was not specifically assessed in our study. The potential impacts of larger organisms on effluent BOD_5 levels are a potential area of future study.

FIGURE **1**

Least Squares Means of BOD_5* in Septic Tank Effluent From Treated and Nontreated Tanks During Individual Sampling Events Based on a Two-Factor ANOVA



*Five-day biochemical oxygen demand. The first sample analyzed was taken four weeks after initiation of additive application. Normal range is 150–250 mg/L as per Crites & Tchobanoglous (1998).

TABLE **1**

Type 3 Test of Fixed Effects at α = .05 Level

Parameters	Effects	*p*-Values
BOD_5[a]	Treatment	**.0384***
	Time	**.0245**
	Treatment*time	.6250
TSS[b]	Treatment	.3428
	Time	.0620
	X*treatment	.6066

[a]BOD_5 = five-day biochemical oxygen demand.
[b]TSS = total suspended solids.
*Numbers in bold are significant at α = .05.

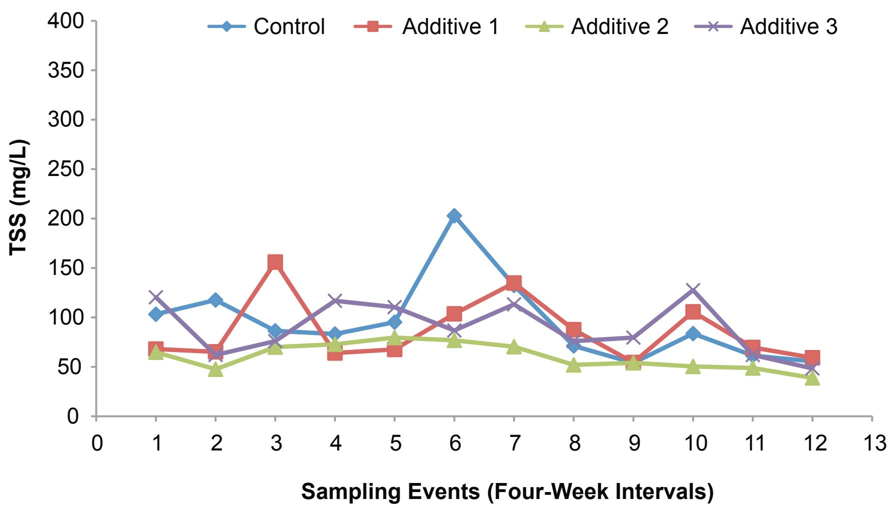
TSS

TSS were also measured to determine whether biological additives affected this aspect of effluent quality. The average TSS values measured (Figure 2) were within typical ranges (40–140 mg/L) for effluent from septic tanks not equipped with effluent filters (Crites & Tchobanoglous, 1998). The average septic tank effluent TSS contents followed the same pattern as effluent BOD_5 concentrations. The control tanks had the highest TSS content (LSM = 95.5 mg/L; $SE = 17.3$) followed by additive 3 tanks (LSM = 89.9 mg/L; $SE = 17.0$), additive 1 tanks (LSM = 86.3 mg/L; $SE = 17.0$), and additive 2 tanks (LSM = 60.5 mg/L; $SE = 17.0$).

As in the case of BOD_5 concentrations, tanks treated with additive 2 maintained

FIGURE **2**

Least Squares Means of Total Suspended Solids (TSS) Contents in Septic Tank Effluent From Treated and Nontreated Tanks During Each Sampling Event Based on a Two-Factor ANOVA



The first sample analyzed was taken four weeks after initiation of additive application. Normal range is 40–140 mg/L as per Crites & Tchobanoglous (1998).

lower effluent TSS concentrations than control tanks throughout the study period (Figure 2). No such consistent TSS pattern was observed for tanks treated with additive 1 and additive 3.

Additive TSS contents were 6%–38% less than the control, depending on the types of additive used, but not significantly different than the control. A two-way ANOVA indicated no significant overall treatment effects on effluent TSS concentrations at an $\alpha = .05$ level (Table 1). Dunnett's *t*-test was performed at $\alpha = .05$ to check for significant effects of specific additives on effluent TSS concentrations. Dunnett's *t*-test indicated that none of the effluent TSS concentrations for additive treated tanks was significantly lower than the control (additive 1: adjusted $p = .9450$; additive 2: adjusted $p = .2237$; additive 3: adjusted $p = .9865$). The effluent TSS levels in treated tanks illustrated an inefficiency of bacterial additives on improving flocculation and settling of suspended solids. While the time effect for effluent TSS was not significant at $\alpha = .05$, it was close (Table 1).

Effluent Quality Discussion

Average septic tank effluent TSS concentrations from treated as well as control tanks were generally lower than the threshold maximum septic tank effluent TSS levels set by the North Carolina Department of Environment and Natural Resources (TSS < 100 mg/L) for domestic wastewater (NCDENR, 2008). Average effluent BOD_5 concentrations in septic tank effluent from additive tanks as well as control tanks were also lower than the threshold maximum septic tank effluent BOD_5 levels (BOD_5 < 350 mg/L) set by NCDENR (2008) for domestic wastewater.

BOD_5 and TSS values showed that septic tank effluent from the control tanks had higher wastewater strengths than the additive-treated tanks. Statistical significance of the treatment effect on effluent BOD_5 concentrations indicated that a higher digestion rate of organic wastes in the additive-treated septic tanks was likely. Digestion rates were not directly measured, however. Treatment effects on TSS concentrations were not statistically significant. The effluent TSS levels in treated tanks indicated that biological additives did not have any positive effect on flocculation and settling of suspended solids. This could possibly be explained if higher digestion rates increased gas production thereby floating solids as they become attached to gas bubbles and releasing these solids as TSS in the effluent. Some jurisdictions utilize gas deflection baffles below the septic tank outlet tees to minimize this negative effect of active digestion in septic tanks. Gas deflection baffles were not used in the septic tanks studied here.

Value Assessment of the Additives Tested

Besides assessing effluent BOD_5 and TSS concentrations, one of the objectives of this project included assessing the overall impacts (positive, negative, or no effect) of biological additives on septic tank performance. Hence, the effluent BOD_5 and TSS results obtained here for 20 recently pumped septic tanks are compared with Pradhan and co-authors' (2008) outcomes from additive impacts on microbial population and Pradhan and co-authors' (2011) assessment of additive effects on solids accumulation for 48 septic tanks with various prior-maintenance histories (Table 2). Summary assessments are provided from two viewpoints. One viewpoint is on the basis of the specific additives tested (i.e., individual assessment of each of the three additives). A second viewpoint is based upon the relative level of prior maintenance provided to the septic tanks (i.e., three maintenance levels defined by pump out history and initial solids levels).

Additive 1 Impacts

Additive 1 septic tank effluent had 16% and 10% average lower BOD_5 and TSS concentrations compared to the control in highly maintained sites (Table 2). Treatment effects were not statistically significant (adjusted $p = .2031$ for BOD_5 and adjusted $p = .9450$ for TSS), however, at the 95% confidence level. Like effluent quality, sludge depths and total solid accumulation in tanks treated with additive 1 were 21% and 15% less than the control, respectively. Numerically, the additive 1 tanks had lower sludge depths and total solids accumulations and higher numbers of CFUs than control tanks, although the results were not significantly different (Table 2). So we concluded that additive 1 had little to no value as an additive for the conditions tested here.

TABLE **2**

Impacts of Biological Additives on Microbial Populations, Solids Accumulation, and Effluent Quality Throughout a Broad Range of Septic Tank Maintenance Levels

Septic Tank Concentration	Parameters Measured	Treatments	Highly Maintained (LSM)*	Dunnett's *t*-Test	Intermediately Maintained (LSM)	Dunnett's *t*-Test	Poorly Maintained (LSM)	Dunnett's *t*-Test	Overall Treatment Effect (*p*-Values)
Organisms (48 tanks)[a]	CFU log (CFU/mL)	Control	5.5	–	5.8	–	5.3	–	.9194
		Additive 1	5.7	0.9758	5.3	0.4937	5.8	0.9786	
		Additive 2	5.2	0.9983	5.5	0.4050	5.8	0.6471	
		Additive 3	5.2	0.9719	5.7	0.8962	5.6	0.9999	
Solids (48 tanks)[b]	Sludge (cm)	Control	33		29	–	45	–	.2245
		Additive 1	26	0.1573	33	0.2853	44	0.9737	
		Additive 2	24	**0.0450****	36	**0.0481**	40	0.3144	
		Additive 3	23	**0.0194**	26	0.6157	42	0.8706	
	Scum (cm)	Control	***	–	1	–	4	–	.7138
		Additive 1	***	n.d.[f]	1	1.0000	7	0.3211	
		Additive 2	2	n.d.	1	0.9999	6	0.6513	
		Additive 3	2	n.d.	2	0.8475	4	0.9999	
	Total (cm)	Control	33	–	31	–	49	–	**.0023**
		Additive 1	28	0.3381	38	0.0786	52	0.5272	
		Additive 2	27	0.1660	37	0.0998	45	0.3705	
		Additive 3	27	0.1544	28	0.4433	48	0.9773	
Effluent (20 tanks)[c]	BOD_5[d] (mg/L)	Control	252	–	n.d.	n.d.	n.d.	n.d.	**.0384**
		Additive 1	211	0.2031	n.d.	n.d.	n.d.	n.d.	
		Additive 2	184	**0.0131**	n.d.	n.d.	n.d.	n.d.	
		Additive 3	226	0.5443	n.d.	n.d.	n.d.	n.d.	
	TSS[e] (mg/L)	Control	96	–	n.d.	n.d.	n.d.	n.d.	.3428
		Additive 1	86	0.9450	n.d.	n.d.	n.d.	n.d.	
		Additive 2	61	0.2237	n.d.	n.d.	n.d.	n.d.	
		Additive 3	90	0.9865	n.d.	n.d.	n.d.	n.d.	

[a]Data from Pradhan et al., 2008.
[b]Data from Pradhan et al., 2011.
[c]Data from current study.
[d]BOD_5 = five-day biochemical oxygen demand.
[e]TSS = total suspended solids.
[f]n.d. = not determined.
*Least squares means (LSM) values have been rounded.
**Bold numbers indicate significant differences at α = .05 level between treatment and control.
***Due to very thin discontinuous scum layers at these highly maintained sites, scum thickness was not statistically assessed. Hence, this parameter was not included for comparison.

Additive 2 Impacts

At the highly maintained site, effluent BOD_5 and TSS levels were 27% and 38% lower, respectively, than the control in additive 2 tanks. While BOD_5 effluent concentrations in tanks treated with additive 2 were significantly lower than the control (adjusted p = .0131), TSS concentrations were not (adjusted p = .2237). In tanks treated with additive 2 at the high-maintenance level, sludge depths were significantly less (27%) than the control tanks (adjusted p = .0450) and total solids accumulation was 18% less than the control, which was not low enough to be significantly different (adjusted p = .1660).

The reduced sludge and the total solids accumulations in the recently pumped septic tanks and the BOD_5 and TSS concentrations in effluent leaving these additive 2 septic tanks indicated that application of additive 2 significantly enhanced waste digestion while also reducing effluent BOD_5 concentrations (adjusted $p = .01$). Waste digestion in tanks treated with additive 2 seemed more complete and accelerated compared to control tanks as well as compared to the tanks treated with additive 1 (Table 2).

We concluded that application of additive 2 enhances waste digestion in the recently pumped septic tanks, producing high-quality effluent with lower levels of organic compounds subject to biodegradation in the drain field. By contrast, at the intermediate-maintenance level, this additive had a significantly negative impact (adjusted $p = .0481$) on sludge accumulation, increasing average sludge production 24% from a 29-cm depth to a 36-cm depth, rather than decreasing it. Additive 2 had no significant impact at the poor-maintenance level. These results indicated that a positive overall impact of additive 2 to septic tank performance only occurred at the highly maintained sites where tanks were pumped 2–3 years previously. Additive 2 should not be used in tanks that have been pumped more than 2–3 years previously, due to negative impacts.

Additive 3 Impacts

Tanks treated with additive 3 had lower BOD_5 (10%), TSS (6%), sludge depth (30%), and total solids accumulation (18%) than control tanks at the high-maintenance level. While sludge depths were significantly reduced in treated tanks at the highly maintained site, microbial contents, BOD_5, TSS, and total solids accumulation were not (Table 2). Additive 3 did not show positive (or negative) treatment effects for any of the parameters tested at intermediate and poorly maintained sites. These results indicated that additive 3 had a pragmatic positive impact in recently pumped septic tanks (pumped within 2–3 years). At the high-maintenance site, additive 3 significantly reduced sludge levels and produced a high-quality effluent, introducing enhanced digestion compared to the control in recently pumped tanks. It did not significantly increase effluent BOD_5 and TSS contents compared to the control.

Prior-Maintenance Impacts

No consistently positive additive impacts occurred overall on septic tank function and performance across all additives tested for all the three maintenance levels assessed for any of the wastewater parameters studied. None of the additives tested had significantly positive treatment effects on microbial populations at any maintenance level. The biological additives studied here had no statistically significant treatment effects on effluent TSS concentrations overall. Effluent filters can be used, however, to limit discharge of TSS in septic tank effluent.

In summary, biological septic tank additives as a collective group had no demonstrably positive impacts across all maintenance levels studied. It appears nevertheless that some septic tank additives may have selected positive or negative effects on sludge depth or effluent BOD_5 quality under specific prior-maintenance conditions, such as the following.

Poorly Maintained Septic Tanks

At poorly maintained sites, none of the additives tested had significantly positive or negative treatment effects on any of the parameters tested, indicating that no significant additive impacts were present. Based upon research results, we concluded that use of septic tank additives should not be recommended on poorly maintained tanks.

Intermediately Maintained Septic Tanks

At sites with an intermediate-maintenance level, none of the additives tested had significant positive or negative treatment effects on any of the parameters tested, except sludge levels in tanks treated with additive 2. Significantly greater (24% greater) sludge depths in treated tanks showed a net negative additive 2 effect at an intermediate level of maintenance. Again, we conclude that septic tank additives should not be recommended for these types of tanks.

Well-Maintained Septic Tanks

In the well-maintained septic tanks,

- additive 1 did not show significantly positive effects on any of the parameters tested;
- additive 2 had significantly positive effects on reducing sludge accumulation rates compared to the control as well as on reducing effluent BOD_5 concentrations, indicating a positive effect for recently pumped septic tanks; and
- additive 3 had significantly positive effects on reducing sludge accumulation rates compared to the control and did not cause an increase in effluent BOD_5 or TSS concentrations discharged from the tanks, thereby also indicating a positive effect overall for recently pumped septic tanks.

Hence, we conclude that some specific additives can reasonably be recommended for use in recently pumped septic tanks to enhance anaerobic digestion. The data do not support elimination of septic tank pump outs since net gains in solids over time occurred within these tanks that received additives. In addition, our research indicates that application of septic tank additives without recent pumping of the septic tank is not a recommended course of action.

Conclusion

Our study highlights some newly understood potentially positive efficacies of biological additives on septic tanks at well-maintained sites where septic tanks have been recently pumped (within 2–3 years prior to the additive usage). Only three of the 1,200+ septic tank additives on the market were studied here, however, and no positive effect occurred overall for additives as a collective generic grouping. This result is consistent with the recommendations of Clark (1999). Our general conclusion is that additives (as a category or collective grouping) do not show a positive impact on septic tank function and performance. In addition, the variability in specific additive impacts within recently pumped tanks leads us to conclude that the general public could benefit from a national or international additive testing and certification program. Such a certification program could identify and ascertain the efficacy of specific additive products. Thus, we recommend that certification organizations like NSF International and Underwriters Laboratories, Inc., in concert with professional organizations such as NEHA, collaboratively work with industry to support the development of an American National Standards Institute national standard for identifying and certifying specific additives that can benefit septic tank function in septic tanks that have been recently pumped.

We recognize that the results presented here and in Pradhan and co-authors (2008, 2011) represent only one assessment. We note that the results obtained here may be different for other sets of environmental and experimental conditions. Therefore, replicated, controlled field research on full-scale septic tanks should continue in order to verify and extend these findings about the application of biological septic tank additives. In particular, we recommend that the positive impacts of selected additives observed here need to be confirmed in a pilot study to develop a specific proposed certification protocol for field testing of additives in recently pumped tanks.

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