Clean Water Notebook

Disposal of Sewage From Pump-out Stations

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Vessel Sewage Characterization

The safe and sanitary disposal of vessel sewage waste must be provided for when installing and operating pump-out stations and waste reception facilities. Boaters will not spend time and money discharging their boats properly unless they can be assured that every effort has been made to improve water quality.

Vessel sewage is more concentrated than domestic sewage for almost all of the standard parameters which are used to measure the properties of waste water, including suspended solids, biological oxygen demand (BOD), and total nitrogen content. Raw municipal sewage has lower concentrations of these because people on land use larger volumes of water for sanitary purposes than do people on boats. The dilution from gray water (defined as water from baths, showers and kitchens and storm water) is also greater in municipal sewage and collection systems.

Source	Typical BOD levels
Boat Sewage	1700-3500 mg/l
Raw Municipal Sewage	110-400 mg/l
Treated Municipal Sewage	5-100 mg/l

Another characteristic of vessel holding tank effluent is the presence of chemical additives which have been used to disinfect and deodorize the waste. These same additives are used to treat sanitary wastes in recreation vehicles (RVs), trains and aircraft. Ideally, odor-control chemicals should be biodegradable when diluted, although they commonly contain active disinfectants in addition to dyes and perfumes. Some of the more common disinfectants include formaldehyde, paraformaldehyde, quaternary ammonium chloride, and zinc phosphate[2]. Formaldehyde is the most popular because of its effectiveness in killing odor-causing bacteria.

There is some concern from operators of small municipal and package sewage treatment plants, as well as from some marina operators who use septic systems, that holding tank waste may adversely affect the efficiency and performance of their sewer systems by destroying bacterial populations. A second concern, particularly from operators of municipal treatment plants which operate at or near capacity, is that the additional volume of waste will cause the plant to exceed its capacity to treat waste water.

Research into the effects of chemical additives on sewage treatment processes indicates that these problems have been greatly overstated, and that, in general, most municipal sewage treatment plants can handle vessel holding tank waste without difficulty. In addition to relatively low, regular volumes of waste generated by pump-out stations, the weekly and seasonal usage patterns of marina facilities

Vessel Sewage Characterization (continued)

protect treatment systems from failing or exceeding capacity. Marinas receive their largest pump-out volumes on weekends and, in many parts of the country, only during the summer season. Therefore, treatment plants generally are able to accommodate such intermittent waste loading with no serious operational problems (See additional information in appendix).

Despite their negligible effect on sewage treatment processes, general concern about additives and toxic contaminants has led to the development of non-toxic, environmentally-benign holding tank deodorants and disinfectants. The use of these products should be encouraged.

Disposal Methods

A description of the relative merits of each of these methods appears in the next section. It should be noted that each State has its own regulations and policies regarding what it considers "appropriate" disposal methods. What one State considers appropriate or desirable, another may prohibit.

Sewage disposal methods will vary depending on a number of factors including: State and Local sanitation codes, the number of recreational vessels and where the vessels are congregated, the availability and geographic proximity of existing treatment facilities to boating centers, and hydrogeologic characteristics, including soil types and groundwater flows. Marinas may consider the following methods based on these factors.

1. Off-site treatment:
   a. Discharge to a public waste water collection system and treatment facility.
   b. Discharge to a holding tank with removal and transport by a licensed septage hauler to a municipal septage receiving and treatment facility.
2. On-site treatment at marina:
   a. Discharge to a package treatment plant with subsequent discharge back into coastal waters (an NPDES permit would be required).
   b. Discharge to a septic system, where no other alternative is available.

Off-Site Treatment

There are hundreds of existing municipal wastewater treatment facilities which serve coastal areas throughout the country. Most provide at least secondary treatment which utilizes an activated sludge process, but they vary greatly in size and details of treatment structures, sludge handling capabilities, and success in meeting current permit terms and conditions. Many also incorporate septage receiving and treatment facilities into their overall treatment systems.

Septage receiving/treatment facilities are designed specifically to pre-treat waste before introducing it to the wastewater treatment system. Because vessel holding tank and portable toilet waste is similar in nature to domestic septage (although more concentrated with variable amounts of organic chemicals), a properly operating municipal treatment plant with septage receiving/treatment facilities should not be adversely affected by the introduction of holding tank waste.

Off-Site Treatment (continued)

Pump-out station holding tanks should be sized appropriately for the volume of sewage generated and the frequency that materials are removed from the holding tank[3]. State and Local requirements may govern the size of holding tanks, although generally, a 1,500-gallon holding tank can serve up to 100 boats with permanent toilet systems. In terms of the number of boats serviced with a normal removal schedule, the following minimum tank sizes are suggested:

Total Number of Boats Serviced With Holding Tanks	Recommended Holding Tank Volume (gallons)
1-20	300
21-40	600
41-60	900
61-80	1,200
81-100	1,500
100+	2,000

On-Site Treatment and Septic Systems

On-site treatment at a marina may be a viable alternative when the marina is not located near sewer lines, when transport of waste is prohibitively expensive, when the local sewage treatment plant is unable to accept additional discharges, or when groundwater and coastal waters can be protected. On-site treatment eliminates the need to transport waste. However, the proliferation of small, potentially troublesome treatment systems often creates more water quality problems than the collection of vessel sewage is intended to solve, including coastal and groundwater contamination.

Package Treatment Plants

Package treatment plants offer an alternative for the treatment of boat vessel sewage and waste generated by marina restrooms and other shoreside sanitary facilities. They are usually small, pre-fabricated sewage treatment plants that provide secondary treatment by using the extended air mode of operation. Treatment is accomplished by introducing air into the waste water to encourage more growth of the aerobic bacteria which digest the sewage, and thereby provides a high degree of treatment.

Discharging vessel sewage to a package treatment plant should only be considered by boating facilities with large treatment systems that can handle the increased shock load and chemical additive present in this type of waste. The typical problems with such systems are exacerbated by the nature of holding tank waste. Like septic systems, package plants are designed to deal with sewage with low solids content and are highly dependent on maintaining an environment that is not toxic to the treatment bacteria. Holding tank waste is concentrated, which may raise treatment and sludge handling issues. Normal difficulties with treatment processes would be worsened by the slug flow nature of the discharges to a package treatment plant, though they can be eliminated by “bleeding” the influent into the plant. In addition, the waste may contain metals and hydrocarbons which can destroy the treatment process.

Based on these concerns, States may not want to encourage the development of small sewage treatment plants due to the variability of effluent quality, as well as substantial difficulty in maintaining proper operation of the mechanical components of such systems.

Septic Systems

Septic systems are the conventional on-site sewage treatment systems found throughout the United States. They consist of septic tanks which treat primary waste through floatation, settling, and the digestion of the accumulated sludge. Effluent from the tank is directed to subsurface leaching systems which provide additional treatment by establishing a biological crust. The permeability of the biological crust is a direct function of the BOD and suspended solids in the effluent stream. Once effluent leaves the crust zone, it enters a soil environment where, if the septic system has been properly sited, a number of treatment processes produce a high quality final effluent. The size and location of the leaching system or drain field is extremely important because the quality of the final treatment is highly dependent on the type and quantity of the soil through which the effluent will pass.

In general, septic systems are not a favorable option for the disposal of vessel sewage because they are not designed to treat the high solid content, high strength, and possibly toxic content of these wastes. They are not very effective at removing trace organic chemicals, and are ineffective at removing nutrients. The chemical additives used to disinfect and deodorize holding tank waste may kill the bacteria that aerobically digest the sewage, and would allow solids to pass through the septic tank and cause the drain field to clog and overflow. (See articles in Appendix concerning acceptable dosage levels.) Nutrients leaching from the drain field may stimulate algae growth in receiving waters, which can reduce the amount of sunlight needed by submerged aquatic vegetation to grow, as well as use up oxygen needed by fish and other aquatic life. In marine waters, nitrogen is the most likely to cause these adverse effects, while phosphorous is the problem in fresh water.

Vessel sewage should be discharged to a septic system only if no other options exist and the system is specifically designed to receive boat waste. Acceptable designs include: using large tanks to manage and "bleed-in" increased flows from pump-out stations; combining flows from ordinary bathroom facilities onshore and the pump-out stations to dilute pump-out wastes; installing two septic tanks in a series to help segregate solids in the first tank and increase retention time in the system; and using a large, properly sited single drain field or alternating drain fields. In addition to following specific design criteria, septic systems should be regularly inspected and properly maintained.

Endnotes

1 This Clean Water Notebook was adapted from USFWS Technical Guideline, Federal Register, Vol. 58, No. 115, Thursday, June 17, 1993.

2 The USFWS Technical Guideline lists zinc sulphate. Several knowledgeable industry representatives indicate that no zinc-based compounds are currently sold in the pleasure craft market.

3 Holding tanks may be installed above or below ground, depending on local codes or health regulations. A conventional septic tank can be modified for this purpose; however, it must be securely anchored in place to prevent the tank from floating when empty or during high-water periods.

Appendix: Reference List of Papers Relating to the Treatability of Holding Tank Chemicals

Mary R. Burrows, Staff Engineer Chemical Development, Thetford Corporation, untitled manuscript, (available from Thetford Corporation, Ann Arbor, Michigan, 1993).

Abstract: This report addresses the treatability of holding tank waste. Included in the article is data on the characteristics of this waste. Also included is information on the holding tank deodorant additives available on the market today, their chemistry and treatability. Holding tank waste can be successfully treated as long as it is handled properly. This waste is much more concentrated than typical domestic sewage. This highly concentrated waste must be taken into account when introduced into the treatment system. As long as the concentration of the waste is accounted for, holding tank waste can be easily treated just as any other waste.

Buchart-Horn Inc. and Versar, Inc., A Survey of the Quantity, Characteristics, and Potential Impacts of Boat Pump-out Waste Generated Within The Chesapeake Bay Region of Maryland (Prepared for: The State of Maryland, Department of the Environment, March, 1992).

Abstract: Review of existing literature suggests that boat waste is an order of magnitude greater in strength than normal domestic waste water. The literature also suggests that direct discharge of full strength boat waste to wastewater treatment processes or septic tanks may cause deleterious impacts to some treatment processes. The findings of the literature review suggest that a dilution of boat waste to normal waste should be 1:7 for activated sludge and fixed film biological treatment processes, 1:13 for anaerobic digestion processes; and 1:1 for septic tank system.

Fred Morris, Technical Director for Consumable Products, SeaLand Technology, Inc., "The Effects of RV and Marine Waste Discharge on Sanitary Treatment Systems," (available from SeaLand Technology, Inc., Big Prairie, Ohio, 1992).

Abstract: This report compares domestic and Recreation Vehicles/Pleasure Craft waste. It also discusses residual treatment chemical levels, load shock, receiving system parameters and possible solutions to shock loading.
The conclusions of the report are:

1. The changes noted in the operating efficiency of sanitary treatment systems are due to the concentration of the RV and/or marine waste introduced and not residual chemicals.
2. A decrease in system respiration is a reversible phenomena directly related to system equilibrium and affected by both controllable and uncontrollable factors.
3. Any process or procedure which effectively reduces the waste concentration factor in the system equilibrium will serve to minimize or eliminate the decreased efficiency of the system.

Frank H. Pearson, Hugh R. McLeon, and Stephen A. Klein, "Pilot-scale septic tank treatment of preservative-laden waste", Research Journal WPCF, Vol. 63, No. 7, (November/December 1991), 999-1011.

Abstract: Recreation vehicle users control odors from water-holding tanks by adding a preservative. Preservatives may impair treatment in plants that receive holding tank wastes. Effects of formaldehyde, zinc, phenol, and quaternary ammonium preservatives on septic tank systems were studied. In batch septic tanks, formaldehyde at 300 mg/L (typical of black water) retarded the degradation of organic solids. Laboratory soil columns receiving 30 or 300 mg/L of formaldehyde, zinc, or phenol removed much of the applied preservative with about the same fraction of incoming soluble COD as for preservative-free control columns. Dosing quaternary ammonium at up to 75 mg N/L did not impair the fractional removal of soluble COD by soil. Freely drained soil removed soluble COD better than did flooded soil. In pilot septic tank-leach field units, 100 mg/L formaldehyde (stabilized with methanol) was not found adverse, and the added nutrient-free carbon even may have stimulated chemical reactions that assimilate nitrogen and phosphate by a mass action effect. Dosing formaldehyde near 300 mg/L produced an effluent similar to that from the control but inhibited sludge degradation. At 1000 mg/L, formaldehyde impaired effluent quality.

Appendix: Reference List of Papers Relating to the Treatability of Holding Tank Chemicals (continued)

John T. Novak, C. Russel McDaniel, and Samuel C. Howard, "The effect of boat holding tank chemicals on treatment plant performance", Research Journal WPCF, Vol. 62, No. 3, (May/June 1990), 288-295.

Abstract: This study was designed to evaluate the effect of shock loadings of odor-control chemicals used in chemical toilets on wastewater treatment processes. Laboratory-activated sludge and septic tank treatment units operating at steady state were spiked with different odor-control chemicals over a 2-day period to simulate dumping of chemicals over the weekend, and their performance was evaluated. Three different chemicals were used, one containing formaldehyde, one containing paraformaldehyde, and a chemical containing dimethylimino ethylene dichloride polymer as the primary odor-control agent. The effect of the chemicals on COD removal and suspended solids discharge and the rate of recovery after shock loading was monitored. Both treatment systems withstood loadings amounting to 25% of the recommended dose for holding tanks without loss of treatment efficiency. At higher doses, a temporary reduction in COD removal occurred, but the systems recovered over a period of several days after chemical addition ceased. The major negative effect on operation was loss of solids due to foaming in the activated sludge systems caused by surfactants in the chemicals.

William R. Walker, Carol Holey, Phyllis Bridgeman, and Steven Goldstein, "Report to the Virginia Department of Health on Effects of Holding Tank Additives on Treatment of Boat Holding Tank Wastes," (Blacksburg, Virginia: Virginia Water Resources Research Center, 13 September, 1989).

Abstract: The information gathered for this report suggests that the major potential problem that would arise in marina septic tank treatment systems if large numbers of boat owners began using pump-out stations would be rapid sludge buildup with a resulting overflow of solids into the drain field. Another potential problem would be the possibility that chemicals remaining in the effluent of the septic tank would act as toxins in the drain field, preventing the drain field from effectively filtering and treating the effluent, or would contaminate surface and/or groundwater. However, the experience of campground operators providing pump-out services for RVs suggests that there is no direct evidence that the septic systems in marinas would necessarily have these problems. Campground operators have had a minimum of problems handling waste from RVs in septic tank treatment system based on one or more of the following factors: (1) the low volume of treated wastes that are pumped; (2) the recovery time allowed by seasonal usage of the pump-out facilities; and (3) the probability that problems were reduced or avoided with such procedures as: (a) dilution of holding tank wastes with additional wastes; (b) alternating use of drainfields; (c) tandem tank arrangements to catch the overflow of solids; (d) enhancing the degradation process with enzyme/bacteria treatments; (e) regular pumping of sludge; or (f) the use of larger tanks that exceed the seasonal demand on the system. The report also recommends issues for further study and regulation.

Frank H. Pearson, et al, "Recreation Vehicle Waste Disposal in Roadside Rest Septic Tank Systems", Report No. FH/CA/UC-80/01, (Berkeley, California: Sanitary Engineering Research Laboratory, University of California, Berkeley, June, 1980).

Abstract: Design criteria were developed for septic tank-leach field systems to treat high-strength waste that may contain toxic substances. High strength, toxic wastes are generated at recreation vehicle (RV) dump stations at roadside rest areas and recreational areas, where septic tank systems are frequently used for waste treatment.

Besides being much stronger than domestic sewage, RV wastes contain toxic preservatives added to the RV waste holding tanks for odor control. Preservatives inhibit degradation of sludge and scum in the septic tank, thereby increasing the net waste, on account of the greater quantity of sludge generated from the high strength waste, compounded by the greater net rate of accumulation of sludge due to the toxicity of the waste.

Preservatives used for odor control in RVs generally contain either formaldehyde, zinc sulfate, phenol, or quaternary ammonium as the active ingredient. Formaldehyde appears to be the most used active ingredient in California. The effect of various concentrations of each of these preservatives on biological activity in septic tanks was evaluated from the reduction in anaerobic gas production and the reduction in the rate of degradation of organic solids in the presence of preservatives.

Whereas a septic tank serves primarily to separate and store the solids fraction of the waste flow, a leach field provides most of the purification of the waste flow due to biological mechanisms in the soil. These waste purification mechanisms may be inhibited by the toxicity of preservative residuals in septic tank effluent. Soil column experiments were conducted to evaluate the effect of different concentrations of the preservatives on removal or organic matter from the waste flow, and to determine the fate of preservatives in soil.

Engineering performance criteria were needed for septic tank-leach field systems treating preservative-laded waste. For this purpose, pilot units treating domestic sewage spiked with various concentrations of formaldehyde were monitored. The mean concentration of formaldehyde in RV black water, 300 mg/L, caused only slight deterioration of effluent quality. About 80 mg/L of formaldehyde appeared in leach field effluent.

Experimental and pilot-plant data describe the effects of preservatives in raw waste on sludge degradation in septic tank systems. These data, together with previously reported operating experience for domestic septic tank systems, are used to develop a septic tank design equation. This equation expresses the detention of a septic tank as a function of the strength and toxicity of the waste, and of the frequency of pumping sludge from the septic tank. Nomographs for design of septic tank-leach field systems are provided.

International Program on Chemical Safety (ICPS), Environmental Health Criteria for Formaldehyde, (Geneva, Switzerland: WHO, date unavailable).

Abstract: This report surveyed available international and national reviews of formaldehyde. Formaldehyde released into the aquatic environment appears to undergo relatively rapid biodegradation. Various activated sludges and microorganisms isolated from activated sludges have been shown to be very efficient in degrading formaldehyde in aqueous effluents, providing the formaldehyde concentration does not exceed 100 mg/L. Essentially complete degradation is achieved in 48-72 hours, if the temperature and nutrient conditions are maintained.

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