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Piggery Waste Management in American Samoa

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Issue

Protection of water resources is critical in American Samoa (AS). Threats to groundwater, surface water, coastal waters and coral reefs are constant. Common threats to surface water include stream-side development, flow modification, loss of riparian vegetation, as well as increased turbidity from development, and nutrient and bacterial pollution from human and pig waste disposal systems (ASEPA, 2006a). Groundwater on the main island of Tutuila is vulnerable because the volcanic stratum is highly permeable and does not have a great capacity to filter. About 99% of drinking water is from groundwater sources.

Waste management is recognized as a major public health and environmental concern for Pacific Island Countries and Territories (SREP, 2006). In AS recent deaths from Leptospirosis, has raised public awareness of the connections between sound waste management and rodent and disease vector control. Because pigs are one of many hosts to leptospirosis, these deaths have raised concerns about the management of local piggeries and the wastes they generate. This increased concern has led to efforts by the American Samoa Environmental Protection Agency (ASEPA, 2006b) to develop guidelines for the management of pig waste in AS (ASEPA, 2006c).

With mounting population pressures, increased waste production, and declining arable land, the safe management of pig waste is a critical issue, especially with respect to ground and surface water quality, and coral reef habitat. The ASEPA asked the Natural Resource Conservation Service (NRCS) along with other entities, such as the Land Grant College (American Samoa Community College) to provide technical assistance and education to improve the pig waste management systems in AS. A considerable effort to provide research and education in small scale animal waste management has been underway for several years by partners of the USDA- Cooperative States Research, Education and Extension Service (CSREES) in the Southwest States and Pacific Islands Regional Water Quality Program (Evensen and Fukumoto, 2007)

In addition to improving overall water quality, while lowering the risk of infection from pathogens, such as leptospirosis, the improved management of pig waste, will improve the use and cycling of plant nutrients found in manure, especially nitrogen and phosphorus, for crop production. Improved waste management will lead to more sustainable agriculture in the islands, while reducing nutrient loading to ground and surface waters.

Background

American Samoa, a U.S. territory, comprises four main islands and is located in the South Pacific Ocean, about half the distance between New Zealand and Hawaii. Along with Western Samoa, it is considered part of Polynesia. Tutuila is the main island with a population of about 58,000 (CIA, 2007). The other islands include Manu'a, Rose Atoll, and Swains Island. The AS economy is dependent on the tuna industry, an infusion of federal funds, and remittances from family members abroad (Craig, 2000).

Rearing pigs in AS is not only an added source of protein, but it is also a very important cultural tradition—a way of life. The intrinsic ceremonial value of these pigs is equal to or greater than their market value (Jennings, 2006, personal communication). The practice of raising pigs has also undergone significant changes over the years as society in American Samoa has changed in response to both external and internal forces. Pigs were formerly raised communally at the village level. All pigs were "owned" by the community and kept in the same location. Maintenance operations were shared by community members. The village chief had overall authority and responsibilities about how and when pigs were consumed and by whom. However, over time pig rearing in American Samoa has become a private affair at the household level. As a result of this privatization and an overall increase in the household income, there are more pigs and they are much more widely dispersed across the landscape.

According to a recent survey, there are about 940 piggeries with a total of 7,800 pigs in AS (ASEPA, 2006), much less than the earlier estimates of 33,000 pigs (CDC, 2004). Common swine management systems include small-roofed pens with concrete or soil pads that are frequently washed or rinsed off with fresh water (wash-down systems). Eighty-two percent of piggeries, which use liquid wash-down waste management systems, are discharging directly to streams or use open-bottom cesspools. Thirty percent of piggeries in the survey do not have enough land to meet setbacks away from property lines or away from streams, and must be permanently closed (ASEPA, 2006b).

Table 1 shows annual rainfall in AS is greater than 100'' and is relatively evenly distributed throughout the year (perudic moisture regime). Irrigating crops with liquid swine waste from wash-down systems is not a viable option because the soil rarely, if ever, dries out sufficiently to warrant irrigation. To effectively use such as system, wastewater storage and soil moisture sensing equipment would be needed, and, even if this type of technology were available, the amount of liquid that could be applied to a given field is much less that that produced by a small piggery using a wash-down system. Data from nine widely distributed climate stations installed by the US Geological Survey and monitored from 1999 to 2004, showed that mean annual potential evapotranspiration as a percent of mean annual rainfall was only greater than or equal to 50 % at two stations (Table 1).

Table 1. Unadjusted mean annual potential evapotranspiration and rainfall. (adapted from USGS, 2000)

	Airport	**Aasufou**	**Masefau**	**Iliili**	**Alava**	**Malaeimi**	**Maloata**	**Matatula**	**Fagaitua**
Mean annual PE inches per day	0.171	0.127	0.121	0.135	0.119	0.108	0.143	0.161	0.13
Mean annual PE (inches)	62.4	46.3	44.3	49.5	43.4	39.6	52.2	58.8	47.6
Mean annual rainfall (inches)	125	178	124	129	145	175	156	96	127
Mean annual PE as a percent of mean annual rainfall.	50	26	36	38	30	23	33	61	38

Coral Reefs and Water Quality

Coral reefs in AS are important to the culture and the traditional food systems of the islands and continue to be a supply of protein in the diets of Samoans . The reefs are under increased pressure from human population pressures. Estimated fisheries catches from the reefs declined 79% from 1950 to 2002 (Zeller et al., 2006). The reefs experienced significant damage from hurricanes in the 90s, and are threatened by over fishing, invading starfish, sedimentation and eutrophication (Green et al., 1999). Six coral reef habitats were assessed on Tutuila to begin to understand the relationship between nonpoint-source (NPS) pollution and coral reef habitat. Using the EPA three-tiered hierarchical system for 'Aquatic Life Use Support' (fully-, partially- and not-supporting), Houk et al. (2005) found that five of the six coral communities were partially supporting, and one was not supporting. The results from the study did not draw any direct links to NPS pollution, as it was a baseline study, but they do show these coral habitats may have a less than desirable degree of aquatic health.

Nitrate contamination to ground and surface waters has been attributed to human and animal waste management. Nitrates were detected in most of the wells monitored on Tutuila (ASEPA, 2006a). Though the detection levels are below 5 ppm of nitrate-nitrogen--the maximum contaminant level is 10 ppm of nitrate-nitrogen--the presence itself is a sign that a potential for increased contamination is very probable with a growing population. According to the ASEPA 305(b) water quality report (2006a), about 79 miles of streams are impacted by animal feeding operations and 86 miles of streams do not meet water quality criteria for nutrients, and 94 miles of streams do no meet criteria for turbidity.

Leptospirosis

In April of 2003, a laboratory confirmed the first case of leptospirosis in the U.S. Territory of AS. (CDC, 2004). Leptospirosis is a bacterial zoonosis and is endemic worldwide (zoonosis is a disease of animals that can be spread to humans). Its occurrence increases following floods and heavy rains and is most common in tropical climates. Leptospirosis is spread by pigs, dogs, mice, rats, and other rodents through urine. The disease has many names: swamp fever (along with malaria), Stuttgart disease and Weil's disease. In Hawaii, it is known simply as "Lepto". In humans it causes a wide range of symptoms, and some infected persons may have no symptoms at all. Symptoms of leptospirosis include high fever, severe headache, chills, muscle aches, and vomiting, and may include jaundice (yellow skin and eyes), red eyes, abdominal pain, diarrhea, or a rash. In rare cases death occurs. Infection in humans is acquired either by direct contact with infected animals or their urine, or in freshwater. It can enter through broken skin and mucous membranes (eyes, mouth, nose).

Leptospira, the organisms responsible for leptospirosis, are present in fresh water and damp soils. They are cork-screw shaped bacteria, and they do not reproduce outside of a host and are reported to survive from 24 days to 7 weeks in the soil, and 16 days in fresh water (Hickey and Demers, 2006; Levett, 2001). The disease does not spread from person to person and has an incubation period of about 5 to 20 days, so symptoms can take awhile to appear. No human vaccine available in the U.S. for the disease; however, domestic animals can be vaccinated against it. The disease is often misdiagnosed because symptoms are similar to other illnesses and incubation is long. It is very difficult to detect in the environment, which is why the most common method of indirect detection is to test people for antibodies to the disease to see if they have been exposed.

In April 2003, the Centers for Disease Control and Prevention (CDC) conducted a survey of 15 villages in Tutuila, AS for Leptospirosis exposure and found a 17% exposure rate (58/341). In 2004, six Leptospirosis cases were identified, with two deaths occurring.

Some of the findings from the report are as follows:

1. Contact with dogs was significantly associated with seropositivity (blood showing antibodies to the disease), whereas contact with rodents and pigs was associated but not statistically significant.
2. Contact with a stream and using stream water for bathing were both significantly associated with seropositivity.
3. Having an annual household income > $21K was found to be protective.
4. Though exposure to dogs was statistically significant and exposure to pigs was not statistically significant, the majority of the antibodies observed in positive blood specimens were two serovars more commonly associated with pigs.

Recommendations from the CDC report included the following:

1. Eradication of leptospirosis is unlikely but improvements can be made.

2. For control, a three-pronged, culturally-sensitive approach was recommended.
    a. reduce the numbers of feral dogs,
    b. control rodents(e.g. poisoning, trimming brush and litter pick-up),
    c. handle pig waste better by moving pens away from streams (e.g. stop direct flushing of waste to streams) and wearing protective gear, such as boots and gloves when handling the waste.

Conservation Planning and Nutrient Management

In addition to controlling the spread of pathogens, managing nutrients is an important part of animal waste management. The NRCS can provide livestock operators technical assistance to develop conservation plans and matching funds through the Environmental Quality Incentives Program (EQIP) to develop and implement a comprehensive nutrient management plan (CNMP) to improve the management of animal waste in livestock operations. Simply put, a CNMP reduces pollution from animal waste through proper collection and treatment methods, by keeping fresh water runoff separate from animal waste, and by utilizing animal waste nutrients in crop production.

Barriers to Effective Implementation of CNMP

The cost of developing a CNMP, and the level of management required for implementing a CNMP are substantial. Developing a CNMP is a large undertaking for any livestock operator, and can be especially difficult for the limited resource farmer (NRCS defines a limited resource farmer in Tutuila as having an adjusted gross income < $19,350). Also, farmers are slow to adopt systems that require increased management intensity, especially if it is not guaranteed to be offset by an increased level of farm income. This increased intensity may include separating waste solids and liquids, composting, collecting and chipping carbon material, planting and harvesting crops associated with manure applications to maintain soil nutrient balances, and record keeping. Even with matching funds from NRCS, the CNMP may require a relatively high capital input from the livestock operators. For these reasons, many pig owners are hesitant to invest in such a system or may be willing to accept a level of risk associated with potential enforcement consequences.

A common constraint in livestock management in island environments is a lack of arable land with a cropping system that can adequately utilize the nutrients from repeated manure applications. In addition, the operator may not have a distribution system to move the manure off-farm to areas where the waste can be used if, for example, the nutrients produced on the farm, exceed the needs of the crops. For the system to work properly, a majority of the nutrients have to be taken up by the crops and eventually leave the farm in the form of agricultural products or in manure that will be used for agricultural purposes elsewhere. The system assures that a balance is made between the nutrients applied and used by the crops and that nutrient-rich runoff or leaching is kept to a minimum.

For efficient composting of manures, moisture balancing and Carbon to Nitrogen (C:N) ratio control are extremely important. A reliable carbon source to maintain this balance is critical to reduce odor and to keep the process efficient; however, a readily available carbon source in AS, such as a yard waste chipping facility, does not exist.

Soil and manure nutrient testing is a requirement for the nutrient management component of a CNMP in order to apply the proper quantities of manure to supply plant nutrient needs and to reduce the potential for polluted runoff and leaching. No commercial laboratory exists in AS, and the Land Grant College does not have a soil testing laboratory. In some cases, soil samples were sent to the University of Hawaii's Agricultural Diagnostic Service Center (ADSC) for analysis, but this is not a good long-term option. Currently, this is not a severe constraint, as demand for the tests is low. But if demand were to increase substantially, this could become a constraint for carrying out nutrient management.

The traditional land tenure system still in force in most of American Samoa also has potentially negative effects on the adoption of alternative waste management practices, particularly those that may involve capital investment in permanent or semi-permanent structures. Land in American Samoa is owned communally at the village level. The village chief assigns parcels of land to individual households for different uses (e.g. housing, agriculture, livestock). Although in practice, this usually results in long-term tenure, the chief has the authority to remove one's use rights to a piece of land at his discretion.

However, this strong traditional system of land use control potentially could work in favor of adoption of new management practices. If village chiefs were convinced that management changes were necessary, they retain the influence and authority, particularly through control over land use, to strongly encourage individual households to change their management practices.

<u>Proposed Alternative Solutions</u>

Alternatives discussed and proposed by different parties to better manage pig waste in AS include the following:

1. Move piggeries at least 50 feet away from dwellings or waterbodies, 100 feet from public drinking water, and 10 feet from nearest property lines. (ASEPA, 2006c); In addition to the setback, NRCS recommends a vegetative buffer between the piggery and the stream.
2. Reduce reliance on water or flushing systems. This reduction could mean encouraging and improving the use of water nipples to save water; converting from a high volume of water used to a low-volume-high-pressure system;
3. Use a dry-litter and composting waste management system (Fukumoto, 2002; ASEPA, 2006c).
4. Implementing a portable pen system (Fukumoto, 2004; ASEPA, 2006c).
5. Growing crops under green-house roof to improve plant uptake of nutrients (Lum, personal communication 2006).
6. Solar drying pig-wastes prior to handling. (No literature exists to support this concept for piggeries, so this may be an option for demonstration purposes. The concept came from the use of solar drying latrines in remote locations, such as on popular hiking trails in the California Sierra Nevada Mountains.)
7. Using pig waste in aquaculture to produce Tilapia. (This option should not be considered because Tilapia are an invasive species and have not yet invaded the fresh water habitat of American Samoa).
8. Using evaporation ponds with water hyacinth growing to take up nutrients. The hyacinth can be harvested and composted.
9. Regulating the numbers of pigs per owner based on their ability to meet critical criteria (e.g. land area, crop system, setback).
10. Implementing experimental and demonstration projects to study the best economic and environmental alternatives to managing pigs in AS.
11. Providing NRCS practice standard variances for AS to allow to manage manure and soil nutrients based on book values and international fertilizer manual recommendations rather than lab samples; and to be able to develop waste storage and waste treatment options prior to developing a CNMP through EQIP.
12. Reduce the contact of pigs with other carriers of leptospirosis, such as rats, mice and dogs through improved pest control and vaccinate pigs against leptospirosis.

Recommended Solutions

Currently, liquid systems for the delivery of raw manure to tree crops are being used in a limited capacity and have been promoted by the Natural Resources Conservation Service (NRCS, no date). However, untreated swine manure should not be put on fields where there is a potential for runoff (Guan, 2003). Similarly, it should not be put on fields when there is a high probability of leaching. Unfortunately, environmental and soil conditions in AS mean that virtually every place where liquid swine manure could be applied will result in either an increased probability of runoff or increased risk of leaching. Although better management of liquid-based systems represents an improvement over current practices, it is neither a sustainable nor a long-term solution.

The most sustainable solution to waste management in AS piggeries is to reduce or eliminate the wash-down or liquid systems, and replace them with the use of covered dry litter or portable pen management systems followed by complete composting. Composts should reach temperatures above 55 °C (130° F to 150° F) to kill most pathogens. The finished compost should either be applied to harvestable crops (preferably grass or tree crops) or moved to areas of nutrient deficient soil, where the nutrients can be used by plants.

Allowing enough time for proper composting is important. In small production systems, it is difficult to ensure that all the bacteria will be exposed to high heat for sustained periods. Also, the reintroduction of live pathogens is possible as fresh manure is added to an existing pile. Two-to four-month composting times have been suggested for small composts to kill E. coli O157:H7 (Guan, 2003). Although very little data is available on leptospirosis mortality related to either desiccation or heat, it is believed that Leptospira do not survive a composting process where the temperature is maintained at 55 °C for 3 consecutive days (Leamaster et al., 1998; Jones and Martin, 2003). Currently a study is underway at the University of Reno, Nevada with Dr. Mark Walker, that is assessing the survivability of leptospirosis under various environmental conditions.

We have little scientific information on the survival of leptospirosis and other human pathogens in swine waste, but we hypothesize that composting is the best low-tech option available for reducing pathogens and stabilizing nutrients prior to applying to crops. Composting pig waste will lead to fewer pathogens contaminating surface water and will help stabilize nutrients for plant uptake. Having adequate plant uptake of nutrients will reduce the potential of nitrogen leaching to groundwater and phosphorus reaching surface water. Composting is labor intensive, because of building, turning and transferring compost piles, but the turning may be facilitated by the use of a cement mixer or tumbler type composters for smaller operations. The person handling the waste may be exposed to pathogens, so precautions are needed.

Additional labor includes collecting carbon material and chipping the carbon material to sizes that are more easily composted. Currently, no centralized yard or green waste recycling system exists on AS. The American Samoa Power Authority recently purchased a wood chipper to shred green waste; however, no system is in place to receive or redistribute the chipped green waste to those who can use it. Public authorities should do everything possible to support a waste-management infrastructure that will provide a sustained level of green wastes that can be used as a carbon source for composting pig wastes. The collection and re-distribution of carbon sources is a key component of successful composting in American Samoa.

The portable pen may be used in conjunction with composting, and ASEPA is recommending this concept (ASEPA, 2006c) but little is known about the survival and transmission of leptospirosis or the cycling of nutrients within these systems prior to composting (Hawkins et al., 2007). Even though technical information is lacking, this system is believed to be more effective at reducing the direct loading of pathogens into surface waters from pig waste, especially if the pens are to be covered.

Protecting pigs from contracting leptospirosis is another important solution to the problem. Reducing the incidents of hosts—wild pigs, rats, mice and dogs—coming into contact with pigs is critical. Reducing the number of stray dogs and breeding places for rats and mice, such as removing piles of refuse, should help alleviate the spread of the disease from one host to another.

NRCS should provide some flexibility in its application of programs and conservation standards to allow limited resource farmers of AS to implement components of the CNMP progressively and possibly provide practice variances that will help overcome some of the obstacles of working with a system of practices designed for U.S. mainland agriculture. These actions might include a variance to the manure and soil testing in nutrient management until a local laboratory becomes available. Book values for manure could be used for calculating nutrient loads, and nutrient recommendations for plant uptake can come from international fertilizer manuals or other reputable institutions abroad. A waiver to Program requirements of developing a CNMP prior to the implementation of a waste storage/treatment facility should be considered to help speed up the process of change in a piggery management system. These actions must be done to lead livestock owners into a more environmentally sound management system than the one he or she currently operates, and it could eventually lead to a CNMP. To eliminate rats and mice as potential vectors of disease, NRCS might consider cost-share for the environmentally sensitive control of rodents through the pest management conservation practice.

Conclusion

Reducing polluted runoff from piggeries in AS will take considerable time and effort and must be supported at all levels of society with strong outreach, education and a consistent enforcement policy. An infrastructure is needed to collect and distribute green waste and provide carbon supplies for composting. Incentives for developing composting systems and reducing the number of pigs being raised near water resources should be provided. Small business grants and other market-based incentives from the federal government could be established.

The capabilities of achieving the recommended solutions for pig waste management in AS are dependent on many factors. Currently, many options for achieving these solutions are being discussed among public officials in AS. However, at the time of this writing, no decisions have been made by government officials pertinent to piggeries management and water quality issues. Pig rearing is very important to the people of AS, and as such, a culturally sensitive issue. Improving pig waste management in AS will not solve the problem of leptospirosis, but it will certainly help alleviate it, while protecting agricultural enterprises. It will improve the agricultural viability of AS and reduce threats to water quality and coral reefs from excess nutrients. Improved dry-litter and composting pig waste manure management systems initially appear to be the best options for dealing with these excess nutrients, which could also reduce dependence on commercial fertilizers for crops, and ultimately lead to cleaner water for a growing population. As the local government moves toward rule-making and enforcement, NRCS needs to position itself to be ready to provide viable technical and financial assistance for clients with piggery operations. This effort will require technical assistance and recommendations from local and regional specialists, as well as national consideration for possible programmatic and/or technical waivers.

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